

Exploring search strategy design to identify diverse literature for inclusion in systematic reviews

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Declarations

This thesis is not substantially the same as any previously submitted or currently being submitted by the candidate whether published or in unpublished form, for a degree, diploma, or similar qualification at any university or similar institution.

I, Claire Michelle Stansfield, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

Signature: _____ Date: 20/7/2018

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Supporting statements

1. Stansfield C, Kavanagh J, Rees R, Gomersall A, Thomas J (2012) The selection of search sources influences the findings of a systematic review of people's views: A case study in public health. *BMC Medical Research Methodology* 12: 55.

Claire Stansfield led on the writing of this paper with input from Josephine Kavanagh and the rest of the co-authors. Claire also analysed the search sources and reviewed the literature. Claire Stansfield, Josephine Kavanagh, Alan Gomersall and Dr Rebecca Rees generated the concept and design of the study. Rebecca analysed the impact of the studies on the systematic review. All authors contributed to early meetings at the development stage of the study and in completing the final manuscript.

2. Stansfield C, Brunton G, Rees R. (2014) Search wide, dig deep: Literature searching for qualitative research. An analysis of the publication formats and information sources used for four systematic reviews in public health. *Research Synthesis Methods* 5: 142-151.

Claire Stansfield analysed the search sources, reviewed the literature and drafted the manuscript. Dr Ginny Brunton and Dr Rebecca Rees assisted with the presentation and design of the study, and in contributing to manuscript drafts. Josephine Kavanagh provided advice on conceptualising the study and Professor James Thomas provided some comments on the manuscript. Claire presented early versions of this study at the Joint Colloquium of the Cochrane and Campbell Collaborations at Keystone, Colorado in October 2010, and at a Social Science Research Unit seminar in July 2010.

3. Stansfield C, Liabo K (2017) Identifying social care literature: case studies from guideline development. *Evidence-Based Library and Information Practice* 12: 114-131.

Claire Stansfield conceived of the study, reviewed the literature and undertook the main analysis. Claire and Dr Kristin Liabo reflected on the findings and drafted later versions of the manuscript. Each contributed their different perspectives in the developing of search strategies for NICE guidelines, with Claire's perspective as an information specialist and Kristin's as the lead systematic reviewer. Claire presented an earlier version of the study at the European Association of Health Information and Libraries (EAHIL), Seville, June 2016, before inviting Kristin to collaborate on the paper.

4. Stansfield C, O'Mara-Eves A, Thomas J (2017) Text mining for search term development in systematic reviewing: a discussion of some methods and challenges, *Research Synthesis Methods* 8: 355-365.

Claire Stansfield undertook the literature review, investigated the applications of text-mining tools for search term development, undertook the case study analysis, and drafted the manuscript of the paper. The case study and selected examples were based on Claire's work in utilising the text-mining tools for various systematic reviews. Dr Alison O'Mara-Eves and Professor James Thomas assisted in reflecting on the findings and editing the manuscript. Jenny Caird provided feedback on early drafts of the parts of the paper relating to an overview of applications of text mining for search term development, and the description of text-mining tools.

5. Stansfield C, Dickson K, Bangpan M (2016) Exploring issues in the conduct of website searching and other online sources for systematic reviews. How can we be systematic? *Systematic Reviews* 5:191.

Claire Stansfield collaborated with the other authors of this paper to develop conceptual understandings and practical implementation of website searching for systematic reviews. Claire led on the writing of the manuscript, finalised the website template and reviewed the existing literature. All authors participated in meetings to identify the issues to address in the paper and all assisted in completing the final manuscript. Dr Ginny Brunton, Dr Alison O'Mara-Eves, Professor James Thomas, Professor David Gough and Jan Tripney participated in early discussions prior to its development into a manuscript. Claire presented an early version of this work at the NICE Joint Information Day in London, November 2014, and in a poster shown the Cochrane Colloquium in Quebec, October 2013.

As co-authors on these reports, we confirm that this information is correct and represents an original contribution by Claire Stansfield to these research projects.




Dr Kristin Liabo

Date: 4th September 2017



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Date: 1st September 2017

Abstract

Systematic reviews used to inform policy-making bring together diverse research literature. Such research literature is identified from a carefully designed search strategy. This thesis explores the search strategy design process for diverse literature, and draws on the findings of five of my research publications. It develops theory from case studies. In doing so, it uses an integrated approach using framework analysis, a thematic analysis and summary to develop higher order themes. These are configured into a model.

My candidate publications centre upon a common theme of designing of search strategies for use in social policy-relevant systematic reviews in public health and social care. The findings of these publications are combined with findings from analysing search strategies I have designed for ten systematic reviews and an examination of guidance and methods literature.

Ten dimensions of search strategy design emerged from the analysis, which comprise four overarching categories: 1) domain and publishing norms; 2) research questions and scope; 3) terminology; and 4) information organisation. Seven dimensions within these categories can be used to characterise diverse literature: multiple subject domains, diffuse dissemination, multiple search resource types, multiple meanings of search concepts, wide search term diversity, broad indexing terms, and the low discriminating power of the search. The remaining three dimensions are integral dimensions to search strategy design though they do not necessarily characterise diverse literature: search sample, establishing search concepts and searching strategy. Seven categories describing the influences of search strategy design are configured from my analysis: people, processes, resources, evidence, technology, standards and creativity and the problem-solving processes within information searching. A model of search strategy design illustrates how the dimensions and categories relate to each other.

Impact Statement

This thesis contributes to methods development in improving the quality and efficiency of search strategies to support the relevance, reliability and timeliness of systematic reviews used in policy decision-making. Systematic reviews of research literature are used to build understandings and inform social policy decisions. The research used for these reviews centre around practice needs rather than discrete areas of research, and is typically diverse in covering multiple subject domains, the variety of approaches to address similar issues and the terminology used in its dissemination. This diversity and fragmentation of relevant literature poses challenges for literature searching using a systematic approach and being confident that the studies collected are representative of the research that exists. Furthermore, the relevant literature must be identified from the volume of research that is continually increasing. While information overload is not a new phenomenon, new developments in the nature and availability of scholarly information systems, research publishing, and automation tools can influence how research literature is identified and how large volumes of literature are navigated. It is therefore important to explore the design of search strategies to inform the adoption of new methods and processes.

The research questions addressed in my five candidate publications emerged from my work in designing search strategies for systematic reviews by policymakers in public health and social care. Each publication contributes to the pool of research on improving the quality and efficiency of search strategies. Their findings inform the approaches used in commissioned systematic reviews used by policymakers, which are undertaken and at the EPPI-Centre, UCL Institute of Education and other institutions worldwide that collaborate with the EPPI-Centre. Collective examination of the publications in this thesis provides an increased understanding of search strategy design for systematic reviews. In doing so, it encourages reflective practice on the meaning of being systematic and implementing appropriate processes. The findings facilitate understanding the opportunities and limitations for identifying diverse literature and aid in developing practical and considered rationales for designing search strategies. They can also assist the critique and development of literature search methods, and communication of the literature search within a review team and with other stakeholders. Some of the material used to prepare the thesis has been incorporated into a commissioned book chapter for library and information professionals, and other findings will inform future research to improve the quality and efficiency of search strategies.

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Chapter 1 Introduction

"The dominant information problems of the future inevitably will derive from the fragmentation of knowledge, a problem shift that may lead to new discovery-oriented views of information searching and use" (Swanson 1993).

"The history of the development of intellectual access to the store of knowledge is the history of the tension between the fluid uniqueness of the individual enquirer and the essential stability and concreteness of the store of knowledge itself" (Neill 1992, p19, cited in Thornley 2009).

This thesis relates to identifying diverse research literature used for systematic reviews. Systematic reviews bring together research to build understandings within an area. Systematic reviews are social and political interventions (Lorenc et al. 2016); they are increasingly used in national and international policy-making to inform decisions about a range of options (Oliver et al. 2015, Dunkel 2012, p218). The relevance of a systematic review to inform policy-making is judged by the policymakers themselves (Oliver and Dickson 2016). Breadth of research evidence informs a range of policy options, and in-depth research evidence enables these options to be scrutinised (Dunkel 2012, p219). However, identifying the evidence is challenging where the research literature is scattered (Francis et al. 2015). There is a tension between identifying and analysing either a broad range and large volume of research literature in order to be relevant to policymakers, or identifying a more manageable, narrow set of research literature that take less time, but may not meet policymakers' needs (Francis et al. 2015, Oliver et al. 2015). In terms of identification of the literature this means designing searches to capture a range of studies spanning across a variety of topics, and in sufficient depth for each topic area.

The design of search strategies has implications for the quality, extent and volume of the relevant research literature contained within a systematic review (Stansfield et al. 2012, Grayson and Gomersall 2003). Because social science literature is dispersed across databases and has variable terminology and indexing, identification requires a range of techniques to counter challenges of scatter (Papaioannou et al. 2009, Grayson and Gomersall 2003). Particular skills are needed for literature searching (Brunton et al. 2017 p104, Petticrew and Roberts 2006 p85). The literature search can take many weeks and further time is needed to screen the literature retrieved against specific criteria. Careful planning is needed to produce high quality systematic reviews that are undertaken in a timely, efficient manner. Therefore, it is important to evaluate methods of designing search strategies to inform practice and to develop them further.

This thesis provides an overview of the search strategy design process and it demonstrates how five of my publications provide a significant contribution to methods for designing search strategies. The findings of these publications are combined with: (1) findings from analysing selected search strategies I have designed for systematic reviews; and (2) findings from an examination of guidance and methods literature. This thesis seeks to inform practice and contribute to theory, with the aim of improving the quality and efficiency of literature searching used for systematic reviews. I establish ten dimensions of search strategy design, configure themes on the influences informing decisions on these dimensions and combine these into a model of search strategy design for diverse literature. The thesis is intended to fulfil UCL requirements for a PhD by publication (UCL 2016). It is set within the domain of social research relating to health and social care.

The background section of this Chapter describes the landscape of literature searching to inform systematic reviews and the context of the thesis. This is followed by a chronological overview of the context of my candidate publications and a summary of key findings. Chapter 2 specifies the aims, research questions, methods and rationale of this thesis. Chapter 3 provides an overview of current guidance and related methodological publications, and draws out some themes on the challenges, influences and gaps in relation to searching for diverse literature. It also explores some of the theoretical literature on information searching to inform the understanding of search strategy design. Different dimensions of searching are developed in Chapter 4. These are used to characterise dimensions of diverse literature, and to demonstrate the contribution of my publications to knowledge. Chapter 5 configures themes of the influences of search strategy design and demonstrates the contribution of my publications in informing these. Chapter 6 concludes with a response to the research questions, discusses implications of the findings and considers the potential for further research.

1.1 Background

1.1.1 Literature search methods for systematic reviews

Systematic reviews are types of research literature reviews. Research literature reviews provide a collation and analysis of research for different purposes and according to different research traditions (Schryen et al. 2015, Grant and Booth 2009). They vary according to the distinct processes of searching, appraisal, synthesis and analysis. The terminology used to describe different types of research literature reviews is inconsistent (Grant and Booth 2009). A systematic review is considered here as a "review of the research literature using systematic and explicit, accountable methods" (Gough et al. 2017 p2). Such methods have internal validity and external transparency of reporting

(Paré et al. 2016). Both the conduct and reporting contribute to the notion of 'systematic' (Booth et al. 2012 p25-28). What specifically constitutes 'research' is defined within the boundaries of individual reviews, and can include both primary and secondary research.

The aim of a systematic review is to build knowledge that is "a more comprehensive and trustworthy picture of the topic being studied than is possible from individual pieces of research" (Oakley 2017, p.xii). Schryen et al. (2015) illustrate six ways that literature reviews build knowledge: synthesising knowledge, adopting new perspectives of knowledge, theory building, theory testing, identifying research gaps and providing research agendas. Given that the distinction between a literature review and systematic review is in the explicit, accountable methods in producing a review, we can infer that systematic reviews could potentially build knowledge in any of the six ways highlighted above for literature reviews. Gough et al. (2017, p3) express this by stating that systematic reviews inform about "what is known, how it is known, how this varies across studies and thus, what is not known from previous research". Although generic principles of literature reviews and systematic reviews traverse academic domains, there are debates within particular domains on the nature of systematic reviews, for example, in information systems (Paré et al. 2016). Discussion on the specific domain influences of systematic reviews does not appear to be present in the research literature, though I consider an awareness of domain is important, as systematic review approaches and methods may vary across domains.

Systematic reviews vary in form to address different needs (Gough et al. 2012). Systematic reviews that are commissioned to address policymakers needs tend to be prompted by problems in practice rather than related to the research available (Francis et al. 2015, Oliver et al. 2015). For example, in the systematic reviews of research undertaken to develop three National Institute for Health and Care Excellence (NICE) guidelines in social care, the research questions were open-ended and it was unclear how well some areas were researched (Stansfield and Liabo 2017). A range of types of systematic review have emerged. Systematic maps are developed from broad and extensive searches of the literature to describe the breadth purpose and extent of research activity within an area, and a sub-set of these studies may be selected for analysis as needed (Gough and Thomas 2017 p56-8). Scoping reviews are used to gain a preliminary overview of a topic to inform decisions on a future review (Gough and Thomas 2017 p49). Rapid reviews vary in terms of reduced time and focus spent on specific stages of review in comparison with other systematic reviews (Petticrew and Roberts 2006, p40). For example, this might involve searching fewer resources or undertaking brief quality appraisal and minimal data extraction. These types of reviews involve systematic approaches

to identifying studies, but may not be limited in the extent of searching, critical appraisal and syntheses of studies (Booth et al. 2012 p25-28).

Undertaking a systematic review generally involves four key activities: identifying studies within scope, describing the studies, critical appraisal of study relevance and quality, and integrating the findings into a synthesis (Gough et al. 2017 p16). As systematic reviews of research are increasingly used to inform policy and practice decisions, their reliability is critically important (Gough et al. 2012). Identifying research literature for use in systematic reviews needs to be undertaken using a clear rationale so that the resulting collection is judged to be either a reliable representation or saturated sample of the available research (Brunton et al. 2017 p96-98). Transparency of these methods is required in order for judgements to be made on the appropriateness of the studies contained within the review (Booth et al. 2012, p23). Some systematic reviews utilise an advisory group consisting of a range of stakeholders; this group informs and validates the reliability of a review at various stages of the process.

'Systematic searching' is considered here as applying a clear rationale to seek out the best available research or a suitable, unbiased, sample of the best research, in order to address specific research questions while being aware that the total universe of relevant studies can never be known (Brunton et al. 2017 p96-98). Authors of reviews make judgements on what is considered such 'best research' and their methods used for the systematic review in a way that is transparent and accountable. Such systematic searching is also used within the family of systematic research outputs, which include scoping reviews, systematic maps and rapid reviews. Systematic searching also underpins evidence reviews that inform the development of guidelines.

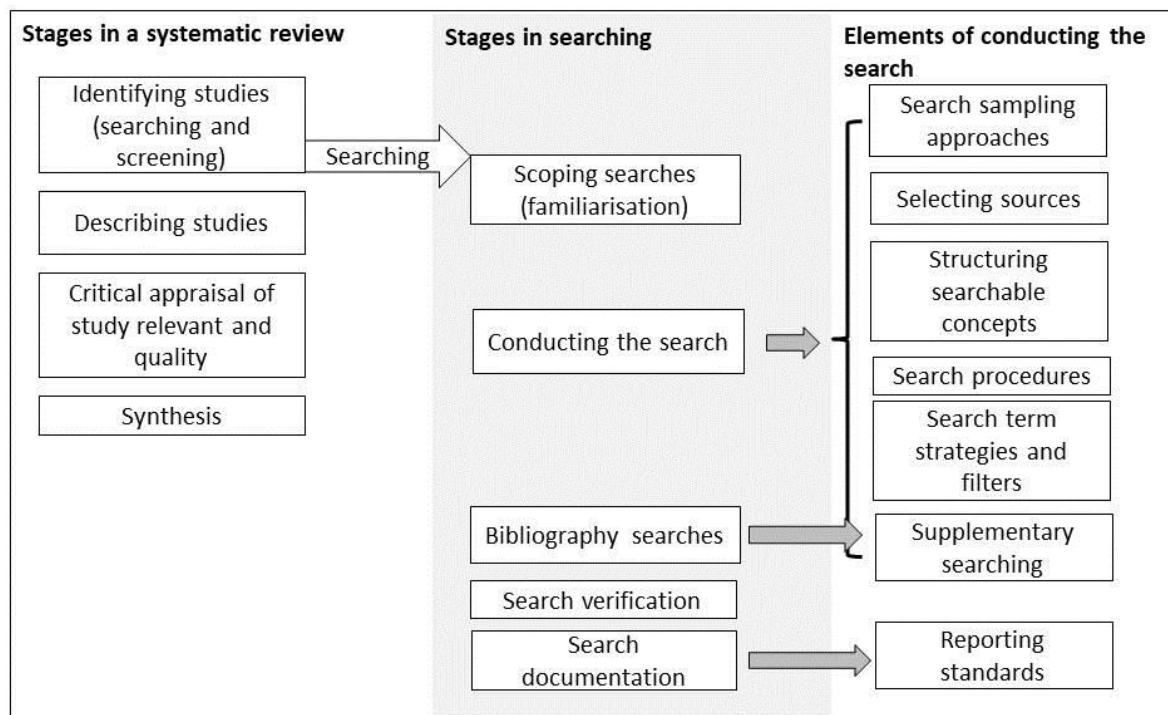
The activity of identifying studies within the scope of a research question includes searching, which is comprised of multiple processes. Figure 1.1 shows five stages of searching, described by Booth et al. (2012, p72), and seven elements involved in conducting the search, described by Booth (2016). Booth (2016) considers 'search procedures' in terms of the level of sensitivity aimed for when conducting database searches, whether the search is undertaken *a priori* or iteratively and a possible association between the extent of database searching and the extent of supplementary searching. The 'bibliography searches' may include checking references, handsearching journals, citation searching, though 'supplementary searching' is wider than this and includes searching websites, contacting authors and searching conference abstracts (Booth 2016, Booth et al. 2012 p72). Stage two, 'Conducting the search', involves designing a 'search strategy', which is a structured plan for undertaking a literature search, and which is the focus of this thesis. Designing a search strategy

comprises many steps and a variety of approaches. In Brunton et al. (2017, p105) we state that a thoughtful search considers the following elements:

- "the aim of searching, ensuring that the appropriate methods are used;
- what the most relevant sources of studies are likely to be;
- the benefits and drawbacks of searching each source;
- the resources available; and for databases searching, appropriate search terms; and,
- the benefits and costs of different combinations of sources within the available resources".

Such considerations are limited by knowledge of methods and resources.

Figure 1.1 Stages and elements of conducting searching for a systematic review (adapts and incorporates stages from Gough et al. 2017 p16, Booth 2016 and Booth et al. 2012 p72)



1.1.2 Methodological development

The methods used for literature searching as part of undertaking systematic reviews relate to two distinct areas of study: methods of systematic reviews, and methods of information searching. Systematic reviewing has only recently become a major area of methodological development (Gough et al. 2017 p9). Searching methods for systematic reviews is a relatively small, but active, research

field. The Scientific Resource Center, which provides support to the US Federal Government's Agency for Healthcare Research and Quality (AHRQ), maintains a bibliography relating to the methodology of searching used for systematic reviews and health technology assessments (SRC methods library, search methods subfile). As of September 2017, it contains over 1,250 citations of research, and over half of these are published within the past five years. Lefebvre et al. (2013) observe an increase in the greater awareness over the past 20 years in information specialists in how to search for studies. The breadth of methods of literature searching is illustrated by Booth's (2016) typology of seven elements of searching, shown in the third column of Figure 1.1.

1.1.3 Focus of my work and the research publications

My five candidate publications for this thesis largely focus on two elements of searching: selecting sources and supplementary searching. Additionally, one publication relates to search term strategies and the use of text-mining (Stansfield et al. 2017). The publications are in the context of literature searching to identify diverse literature for policy-relevant systematic reviews in the fields of public health, social care and international development. They inform practice on two challenges I have encountered in designing search strategies for these topics: choosing appropriate resources and applying methods of searching to these resources to efficiently capture the relevant literature.

During the past ten years I have designed search strategies for many systematic reviews of empirical research and supported others to do so. The systematic reviews I have worked on range from those that address narrowly focused research questions through to broad research questions intended to extensively 'map' out the nature and extent of available literature of a topic. They also include scoping reviews that provide a snapshot of a research area, and reviews that were required to be undertaken rapidly. Some reviews inform NICE Guidelines within the separate areas of public health and social care. All the reviews are commissioned studies undertaken at the Evidence for Policy and Practice Information and Co-ordinating (EPPI)-Centre, UCL Institute of Education. The literature searches use Boolean logic to combine sets of search terms to search within bibliographic databases, and also use of other types of resources (websites, library catalogues, citation searching, and contacting authors). These searches draw on methods used in the EPPI-Centre since the mid-1990s (Peersman et al. 1999). Some of the reviews involved collaboration with research teams internationally. During the course of my work in designing search strategies for systematic reviews I have discussed and collaborated with researchers and information specialists interested in extending and advancing methods for reviewing, particularly those within the Cochrane Collaboration and NICE.

The candidate publications submitted for the degree of PhD by publication consist of three case studies (Stansfield and Liabo 2017, Stansfield et al. 2014, Stansfield et al. 2012); a review and case study (Stansfield et al. 2017) and a discussion paper that explores the methods and approaches of website searching (Stansfield et al. 2016). They are listed in Table 1.1 and the full papers are reproduced in Appendix 1. All these studies briefly review the other literature related to their focus. A book chapter I co-authored concerning methods for literature searching (Brunton et al. 2017) is a supporting publication, as it is cited throughout this thesis. The publications were all externally peer-reviewed. They are co-authored, reflecting the collaborative methods of systematic review research employed by my research team. Supporting statements confirming my contribution for each publication are listed on page 3. My publications listed in Table 1.1 are part of a larger body of published methodological work, systematic reviews that I have either co-authored, or significantly contributed to; this larger body of work is listed in Appendix 2.

Table 1.1 Overview of my publications incorporated within this thesis

Notation in text	Case studies
CP1	Stansfield C , Kavanagh J, Rees R, Gomersall A, Thomas J (2012). The selection of search sources influences the findings of a systematic review of people's views: A case study in public health. <i>BMC Medical Research Methodology</i> 12. doi:10.1186/1471-2288-12-55 Full text at: http://www.ncbi.nlm.nih.gov/pubmed/22520449
CP2	Stansfield C , Brunton G, Rees R. (2014). Search wide, dig deep: Literature searching for qualitative research. An analysis of the publication formats and information sources used for four systematic reviews in public health. <i>Research Synthesis Methods</i> 5: 142-151. doi:10.1002/jrsm.1100 Full text at: http://onlinelibrary.wiley.com/doi/10.1002/jrsm.1100/abstract
CP3	Stansfield C , Liabo K (2017) Identifying social care literature: case studies from guideline development. <i>Evidence-Based Library and Information Practice</i> 12: 114-131.
	Review and case study
CP4	Stansfield C , O'Mara-Eves A, Thomas J (2017) Text mining for search term development in systematic reviewing: a discussion of applications and challenges. <i>Research Synthesis Methods</i> 8: 355-365. http://onlinelibrary.wiley.com/doi/10.1002/jrsm.1250/abstract?campaign=wolibraryview
	Discussion paper
CP5	Stansfield C , Dickson K, Bangpan, M (2016) Exploring issues in the conduct of website searching and other online sources for systematic reviews. How can we be systematic? <i>Systematic Reviews</i> 5: 191. https://systematicreviewsjournal.biomedcentral.com/articles/10.1186/s13643-016-0371-9
	Supporting publication
SP1	Brunton G, Stansfield C , Caird J, Thomas J (2017) Finding relevant studies. In: Gough D, Oliver S, Thomas J (eds) <i>An introduction to systematic reviews</i> . 2 nd edition. London: Sage

1.2 Context and overall findings of my candidate publications

The candidate publications are firstly described from a chronological perspective followed by a description of their individual significance. Their collective contribution and synthesis into new knowledge is considered within Chapters 4, 5, and 6.

1.2.1 Chronological overview of the candidate publications

The research described in my candidate publications was undertaken in an environment where developing and disseminating review methods is encouraged, but moderated by the limitation that funding is largely granted for substantive systematic reviews in social policy-relevant topics rather than for methodological studies. As a result, my research, comprising of methodological studies based on case studies, emerged from practice needs identified during the undertaking of systematic reviews. It is described in two sections: sources of research evidence, and developing strategies for searching specific sources. It is strengthened by a range of perspectives from experienced systematic reviewers, and from the close connection to the context they are set within.

Sources of research evidence

An early methodological study I contributed to was led by Jenny Woodman, and related to exploring the utility of 19 databases to identify research reviews on the effectiveness of social and environmental interventions to reduce obesity in children (Woodman et al. 2010). This research was influenced by a study analysing the utility of search resources for primary studies on intervention effectiveness to promote active transport instead of car use (Ogilvie et al. 2005). Similar research existed on resources for locating primary studies of sexual health intervention effectiveness (Peersman et al. 1999). Analysing the utility of different search resources for identifying public health research is informative for practice, though the extent this is generalisable to different public health topics and study designs is unknown.

An opportunity to explore the utility of databases for locating primary research of people's views in public health arose from my involvement in designing a search strategy for a systematic review of children's views of obesity (Rees et al. 2009). Following circulation of the review protocol to the advisory group, a number of database resources for finding UK-relevant studies in the systematic review of children's views were suggested by Alan Gomersall. The impact of this recommendation was evaluated in my first candidate publication (Stansfield et al. 2012, **CP1**). This case study explores

the impact of 'database selection bias' on the findings of the review and the utility of search sources. At the time there appeared to be no research studies relating to resources for locating qualitative research in public health. Related work focussing on qualitative studies existed in an education topic (Papaioannou et al. 2009).

The questions of what search resources to choose and how to choose them prompted further investigation of the resources and publication formats of studies used four reviews on UK people's views on public health topics, published as Stansfield et al. 2014 (**CP2**). As part of this analysis, ideas emerged around missing items through database searches, and the challenges of searching resources such as websites, library catalogues and search engines. The only study I was aware of that explored publication type and resources at that time was Wilson (2009), which explored this in relation to reviews of effectiveness of crime reduction interventions. Around this time Gomersall and Cooper were reflecting on database selection bias (Gomersall and Cooper 2010) and the potential of UK-relevant resources (Cooper et al. 2015).

Although the research literature in both public health and social care fields are diverse, there is a general perception that social care is more so. I became interested in how social care is different to the challenges of searching within public health topics as part of my work developing search strategies for four social care evidence reviews for NICE guidelines between 2013 and 2017. In Stansfield and Liabo (2017), **CP3**, I compare the search strategies for three guideline topics, determine the utility of different sources for these guidelines and for specific study designs. In addition, I assess how many studies had been missed by the searches on certain databases, which is similar to Bayliss and Dretzke (2006), and Golder et al. (2008). However, unlike their studies which focus on controlled trials, my study also includes qualitative studies and other study designs. This study is also of interest to me because the literature searches for the guidelines were undertaken to address research questions that were driven by social care practice needs and it was not known how much relevant research existed. The potential paucity of research literature, coupled with challenges of identifying it, meant that sensitive, but manageable searches were challenging to design. Therefore, the retrospective analysis in **CP3** is informative to improve understanding of searching in this area. Previous research on the utility of social care resources for specific systematic review topics include Golder et al. (2008), Bayliss and Dretzke (2006), Taylor et al. (2003, 2007) and Brettle and Long (2001).

An attention to the geographical focus of search resources is emphasised in my first case study (**CP1**), and it is important to acknowledge my three case studies include an emphasis on UK views research. However, while the findings on specific databases may be different for research from other

countries, the general findings on database selection bias and literature scatter across databases still apply. The case study in social care additionally draws on international literature containing other study designs (**CP3**).

Over the past five years I have observed a small increase in studies published on sources for use in systematic reviews both within public health and in social care. The studies that cover multiple sources generally centre upon case studies using data from individual reviews, and vary in the study designs they cover. However, other studies centre upon a specific resource and use a sample of systematic reviews; for example, Wright et al. (2015) explore the utility of the nursing and allied health research database CINAHL as a source of qualitative research used in health-related systematic reviews.

Developing strategies for searching specific sources

Another interest I have from designing search strategies is how to use text mining to inform the process. This was influenced by the availability of tools incorporated into EPPI-Reviewer 4, the EPPI-Centre's review management software, and an increased interest within information specialists' networks on text mining. The tools and approaches for utilising text mining appear varied, but are poorly described in the searching methods literature. In Stansfield et al. (2017), **CP4**, I review applications of text mining for search term development. I analyse and reflect on the usefulness of some text mining technologies through a case study and other examples based on my work in using the tools for a number of systematic reviews. The paper also discusses challenges in using text-mining tools.

Techniques for searching websites and databases with limited functionality pose challenges in both undertaking and documenting the searches. The challenges and expectations of website searching became a focus of debate with colleagues through my work in literature searching for international development research. A lack of clarity in how to document these searches was observed during other collaborative research I was a part of (Rader et al. 2014). **CP5** lists the following six challenges of website searching: 1) identifying and deciding which resources to search, 2) how to search or navigate them appropriately, 3) assessing the results, 4) deciding which literature to collect from each resource, 5) retrieving relevant literature in a usable format, and 6) deciding what information to record for transparency. These challenges are pertinent where websites are relied upon to identify important literature for a review, as searching these resources is less transparent, accountable and reproducible than searching bibliographic databases. **CP5** discusses challenges and mitigating solutions in terms of planning the search, executing the search and screening and

information management. **CP5** also explores a wider issue applicable to searching all types of resources, in terms of what it means to be systematic. It was intended to promote discussion and to guide systematic review teams on documenting searches of websites and similar online resources and disseminate a recordkeeping template.

1.2.2 Individual significance of my candidate publications

All five candidate publications have been significant in informing a variety of elements of practice to improve quality and efficiency of designing search strategies for diverse literature. Their individual significance is considered here.

CP1: Influence of search sources on review findings

The key finding of this research is that searching additional resources rich in UK content strengthened the findings and the quality of a systematic review. Although the original search strategy was intended to be comprehensive, searching resources recommended from an advisory group member influenced the review's findings. This research highlighted the importance of regional, topic and population-focused databases that may uniquely contain studies not found elsewhere. Furthermore, it reveals the influence of one person's view (the advisory group member) in shaping the search strategy. Although other research observes the influence of an advisory group on the choice of search resources (Bayliss and Dretzke 2006), my study evaluates the impact of the advisory group on the search results from the resources. Furthermore, it makes a unique contribution to methods by showing the direct influence of searching on the findings of a review, and on improving the quality of studies included in the review. Booth (2016) considers it represents "an important future direction for evaluation of search sources, strategies and procedures". The study demonstrates the subjectivity of a perceived 'comprehensive approach'. The findings of the review informed a later review that was undertaken on the same topic, but focused on young people, rather than children (Rees et al. 2014). The second review searched "two additional databases, and 48 websites and eight library catalogues, compared with 16 websites and two library catalogues in the children's review" (**CP2**).

CP2: Search sources for four public health reviews of UK people's views

The key message of the research is in the title 'search wide, dig deep'. This study investigates resources and publication formats of 229 studies used across four reviews on UK people's views on public health topics. It is significant as there are very few studies that relate publication format with resource type, although others exist on crime reduction interventions (Wilson 2009), and public

health guidelines (Levay et al. 2015). **CP2** is also unique in comparing sources of qualitative literature across several public health reviews. This study is referenced by Booth (2016), along with one other publication, as showing the importance of searching specialist thesis databases in reviews of qualitative research.

Unlike **CP1**, the impact of the sources on the findings of the review was not analysed, as this would have required considerably more resources to investigate than was available. An advantage of the study is that it explores three different review topics in public health and I have used it as a reference point to inform the design of search strategies on related public health topics and on qualitative studies. One finding was that 15 different databases located studies not identified elsewhere (they were found only on one of the 15 databases), and these studies comprised of 49% of the sample. This informs of the benefit of searching multiple databases. As a third of the studies were found in sources other than databases, it indicates reasonable time should be made for searching these resources. The difficulty of searching for books was shown. For two reviews, two journals were shown to be important to hand-search and one of these was through recommendation of the review's advisory group. The study also speculates about domain differences of publication within social sciences; an issue which may not be apparent to cross-disciplinary systematic reviewers. It also describes an example of a study that was indexed in both PubMed and the British Education Index, but was only found from our searches in the British Education Index, owing to differences in indexing of the study citation in the two databases. Therefore, this publication makes a significant contribution to understanding the location and types of literature for qualitative reviews in public health. It also identified a number of specific issues that can inform search strategy design.

CP3: Searching for social care literature to inform guideline development

A potential limitation of the first two candidate publications is that they only rely on the search strategies used within the review, and do not compare this with what is present in a database. **CP3** explores this from both perspectives, providing evidence of what databases are theoretically possible to use, and what databases are useful in practice. It suggests that not locating some citations is variable according to database, topic and individual citations. It identifies a combination of eight databases for finding literature for across three guideline topics that are important to search for. This importance goes beyond yield or topic, to include other aspects of information organisation: database precision, database currency, search functionality and study designs. It draws out specific challenges and opportunities from using individual databases. For example, a more sensitive search of the British Nursing Index (BNI) is possible than with a larger nursing database of

CINAHL as the content of BNI is smaller, and this may yield studies that might be missed in CINAHL. Analysing the citations present within databases by their study design highlighted the predominance of citations of studies about people's views in certain databases. This study also showed variation in the contribution of supplementary searching outside bibliographic databases, across the three guideline topics.

It is particularly important to try to reflect on and articulate why social care is difficult, as there seems to be little published literature describing this in a way that is transferrable to other social care reviews. My study demonstrates it is possible to conduct systematic and useful searches for social care NICE guideline development, which is a relatively new area. It explores challenges in conceptualising searching for guidelines across social care, which uses diverse terminology. It describes how some difficulties of a broad research scope and broad terminology were addressed.

Although this work sits among ten other case studies of social care that examine the utility of databases in social care topics (cited within **CP3**), it explores database utility of different study types, which there is little published on within public health or social care topics. One other publication that does this is Weaver et al. (2002), in relation to research in public health and the built environment. Furthermore, **CP3** is unique in comparing retrieved studies from database searches and missed studies within databases for study designs other than controlled trials.

CP4: Text mining for search term development

This publication reflects on how text -mining tools can be used for search term development for diverse topics. It aims to inform understanding of applying text-mining tools, to improve interpretation of the text mining results and to facilitate increased transparency and dissemination of techniques and methods in using text-mining for search term development. This publication contributes to a gap in the research literature. Related works are the US Federal Agency for Healthcare Research Quality's (AHRQ) white paper on the use of text mining within the various stages of conducting a systematic review (Paynter et al. 2016), and the European Network for Health Technology Assessment's (EUnetHTA) guideline (EUnetHTA 2016), which details the processes for objectively-deriving search strategies, though this is more applicable to clinical topics than to diverse literature.

An important contribution **CP4** makes to the literature is grouping text-mining tools into specific applications for searching, distinguishing between different technologies (word frequency, statistical and linguistic tools) and different ways of utilising them. It develops five overarching purposes of using text-mining tools for designing search strategies, which were drawn from reviewing the

literature: 1) increasing sensitivity; 2) increasing precision; 3) aiding translation across databases; 4) search and screening within integrated systems; and 5) developing objective search strategies. The publication uses a case study to compare the use of different tools in two of the purposes of using text mining: increasing precision and increasing sensitivity. The case study relates to a search strategy that I developed for a set of evidence reviews, which were used to inform a NICE guideline on the social care and support of adults with intellectual disabilities as they age. The findings are strengthened with selected examples drawn from other search strategies I have developed. For example, clustering technology was found to be useful for increasing search precision in the selected examples, but not in the case study. A limitation is that the selected examples do not provide a comprehensive picture of situations where text-mining tools were not useful, as instances of this were not documented. Furthermore, the concept of 'usefulness' is not easily quantifiable as the purpose of text mining is to *aid* the iterative process of search strategy development among using other tools. The paper acknowledges it is difficult to predict the usefulness of text mining for individual studies.

CP5: Website searching

This publication discusses the conduct of searching websites and online resources other than scholarly bibliographic, topic-specific databases in the context of identifying studies for systematic reviews. It discusses approaches from both conceptual and practical perspectives and considers challenges of searching with the principles of being systematic (i.e. based on transparency, accountability and reproducibility). Unlike related published literature, the paper does not frame website searching as only 'grey literature' searching, and it argues that it is also used to identify journal articles not identified from a search of bibliographic databases. The paper proposes considering the search as a three-stage process, to provide flexibility and pragmatism in choosing, searching and browsing websites systematically. The three stages of designing the search, executing the search and screening and information management are applicable to any search resource and the objectives of each stage are described.

A template representing the three stages is proposed as a partial solution to improve the quality of conduct and of reporting of the search of these sources. This candidate publication also draws on practice of published work, and of the experiences of the authors. It emphasises adopting a considered approach to searching that is flexible towards the aims and objectives of the systematic review. It acknowledges the systematic processes used for bibliographic databases cannot be emulated and that it may be undesirable to do so. It is unique in addressing this area. With the increased availability of web resources that do not lend themselves to comprehensive searching, the

paper contributes to the debate of how their benefits can be utilised without compromising searching 'systematically'. Since publication, Haddaway et al. (2017) published findings on transparency in website searching, adding to the methods literature.

In summary, **CP1**, **CP2** and **CP3** evaluate the utility of database sources, though each goes beyond this to explore other aspects related to the search resources. **CP3** additionally discusses challenges of designing the search term strategies in the diverse topic area of social care. The opportunities and challenges of using text mining for search term development is the focus of **CP4**. **CP5** explores website searching for systematic reviews, taking both a conceptual approach and practical application.

Chapter 2 Research questions and methods

A common theme in my candidate publications is the design of search strategies to locate diverse literature for use in social policy-relevant systematic reviews in public health and social care. The purpose of the thesis is to explore my candidate publications and relate this to the research literature and guidance on search strategy design. It aims to generate higher order themes on the design of search strategies for identifying diverse literature in order to increase understanding and inform methods. The thesis addresses the following research questions:

RQ1: What is the current state of knowledge in relation to designing search strategies for systematic reviews of diverse literature (particularly within public health and social care)?

RQ2: How do the findings of the candidate's case studies and the methods used for designing search strategies, as demonstrated in her other publications, collectively inform practice?

RQ3: How do the findings from RQ1 and RQ2 contribute to understanding the design of search strategies for diverse literature?

'Designing search strategies' is considered in this thesis as the approach used to seek out literature from within information sources generally. It does not explore designing search strategies for specific information sources. 'Diverse literature' is considered here as disparate literature that is unified for the purposes of addressing research questions arising from public health and social care through systematic review methods. I establish some dimensions that further characterise 'diverse literature' in Chapter 4.

2.1 Addressing the research questions

The thesis takes an integrative approach by analysing four groups of literatures: 1) guidance and related literature on systematic review methods; 2) theoretical literature on information searching; 3) my candidate publications; and 4) ten systematic reviews, for which I designed the search strategies.

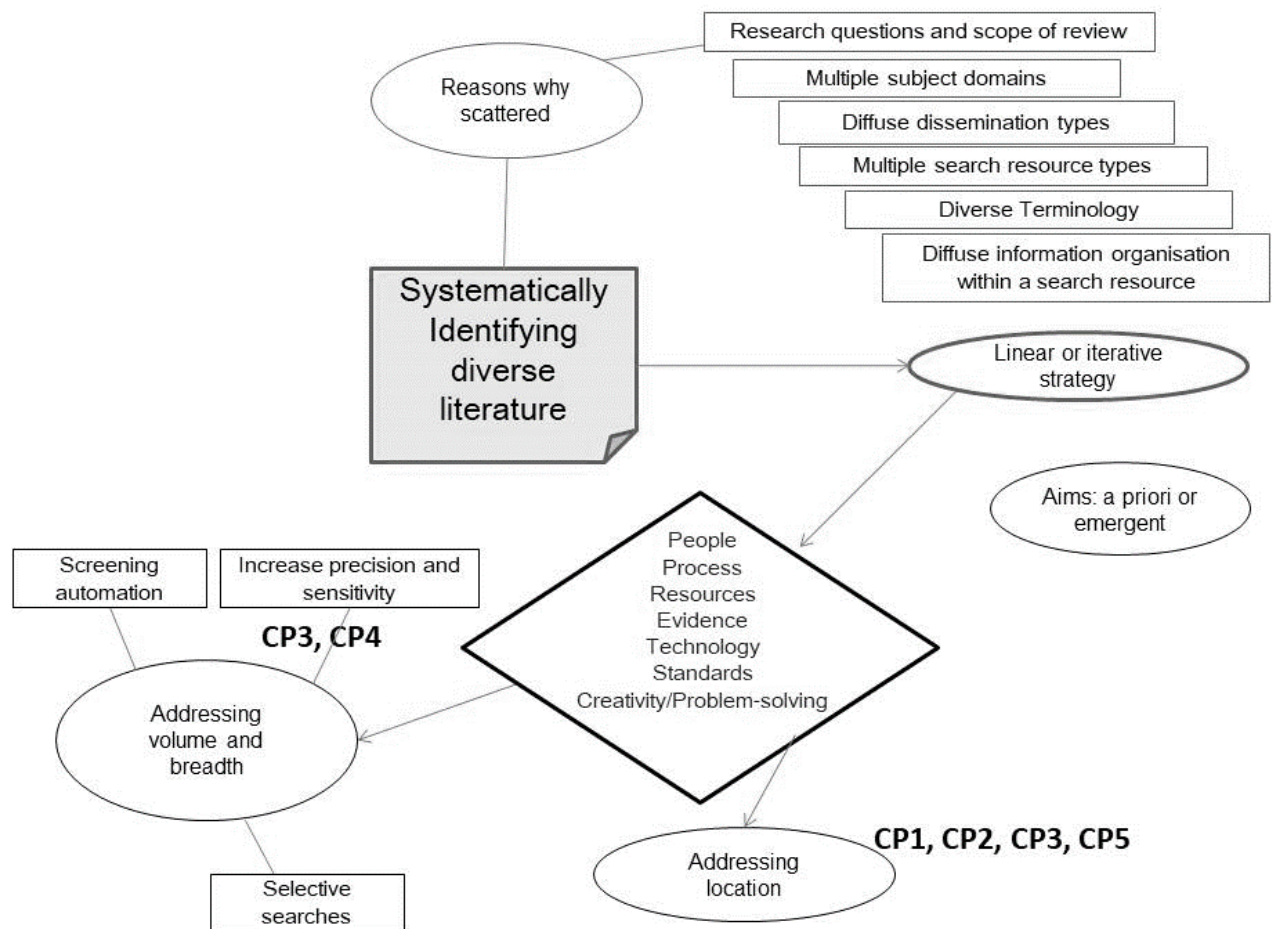
RQ1 is addressed by analysing how guidelines and standards and related searching methods literature approach searching for diverse literature. This analysis includes thematic summaries to reflect on changes in guidance over time, differences of approaches to searching, and challenges and influences of search strategy design. I draw on theoretical literature related to information seeking behaviour to further address this question.

RQ2 is addressed in three ways. Firstly, I reflect on my candidate publications from a chronological perspective, followed by a description of their individual contribution to searching methods (Chapter 1). Secondly, I use a framework analysis approach to compare the search strategies of ten systematic reviews which I designed. These ten reviews were sampled and analysed using the 'dimensions of difference' framework (Gough et al. 2012, Gough and Thomas 2012, p35-66), and additional categories to capture the challenges and influences of designing search strategies. The methods are described further in Chapters 4 and 5 and in Appendix 3. Thirdly, I build a thematic summary of my candidate publications in relation to the challenges and influences of designing search strategies and present this in Chapter 5.

RQ3 is addressed by synthesising the findings from RQ1 and RQ2, to configure three models: 1) dimensions of search strategy design; 2) influences of search strategy design; 3) a model of searching for diverse literature. These are developed from configuring the themes generated under RQ2 within the context of the literature analysed to address RQ1.

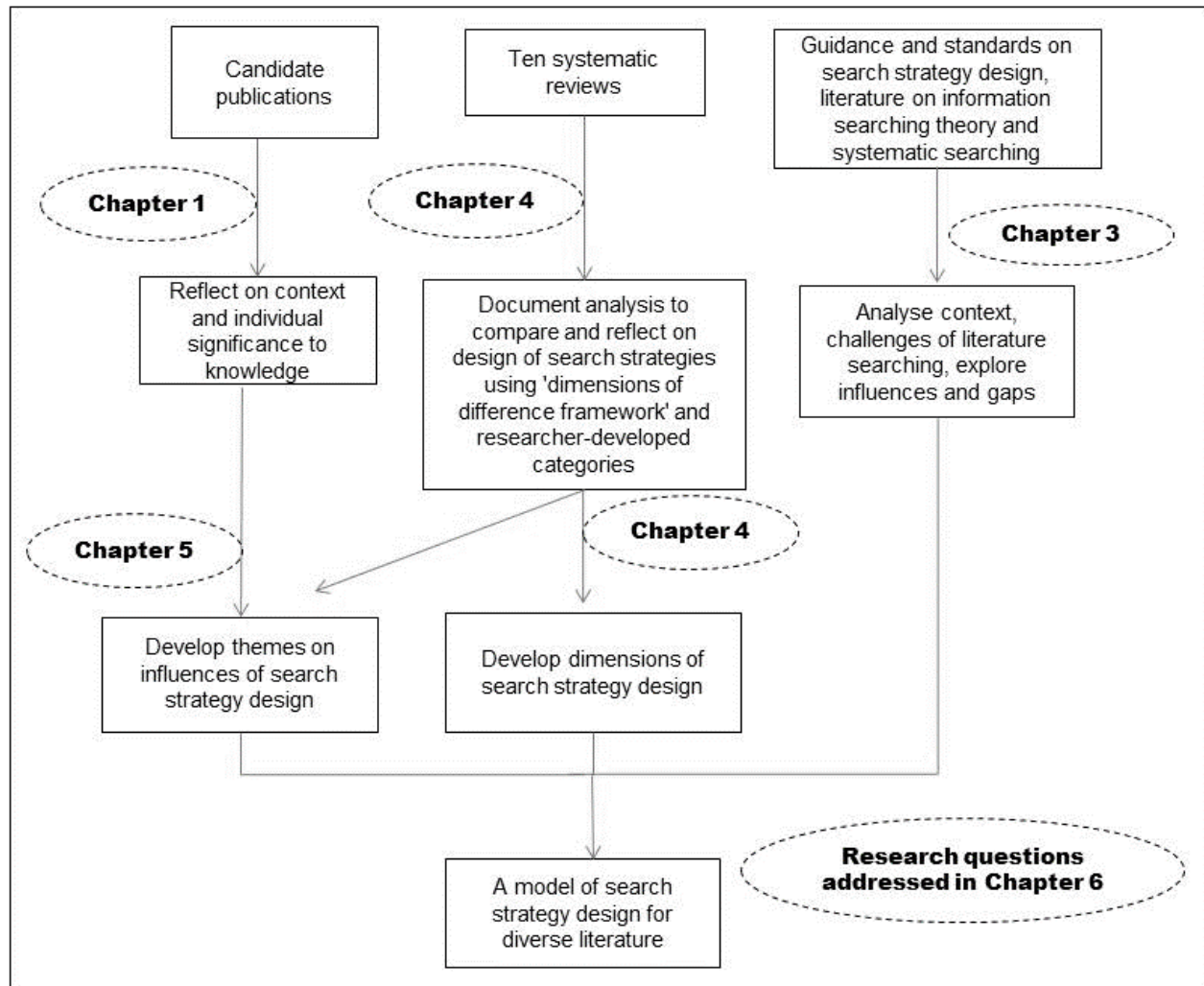
Figure 2.1 shows a model of search strategy design, developed from consideration of the guidance, theoretical literature, analysis of ten reviews and my candidate publications. It also shows the key contributions of my candidate publications in this model.

Figure 2.1 Model of search strategy design and key contributions of my candidate publications (CPs)



The application of the model is discussed in Chapter 6 in response to RQ3. The model was developed as a way of configuring the issues identified from considering the literature cited in Chapter 3, the analysis of ten reviews in Chapter 4, and my candidate publications. The perspective was from considering: the reasons why the literature is diverse; the influences on search strategy design; and the different approaches to search design from information overload and from the nature of the research question. The influences on searching are an important part of the model as they demonstrate the dynamic, social and creative elements of the process. Figure 2.2 shows a map of the thesis.

Figure 2.2 Map of thesis showing how the different analyses are used to understand the design of search strategies for diverse literature



2.2 Rationale

An integrated approach is used to gain a perspective on search strategy design for diverse literature. My candidate publications explore selected elements of search strategy design from retrospective analyses, and reviewing literature and reflecting on practice from case studies. The sample of ten reviews provides insights on a broader range of elements of search strategy design than is covered in the candidate publications, though does not evaluate the utility of the approaches used towards these elements. Though the sample was selected to provide a range of different insights into searching for diverse literature; it is not representative of all potential search strategies for diverse literature. Therefore, incorporating additional literature to inform findings provides strength and perspective to my findings. An important aspect of building theory from case study research involves

drawing on existing literature; this "sharpens generalisability, improve construct definition and raises the theoretical level" Eisenhardt (1989 p533). The holistic, configurative approach for gaining understandings from document analysis has justification from the literature. For example, Bawden (2012) reviews and compares methods for gaining 'understanding' in information documents within an information science research context, and argues that such methods are qualitative, holistic, inductive and non-linear.

The models developed on designing search strategies seek to construct a generalisable reality from my interpretive findings. The models are informed by my candidate publications, which provide some objective findings, and are strengthened by combining observations from different literatures. The models draw on my experiences and perspective of undertaking literature searching. The categories and dimensions of searching are intended to be generalisable, though the nature of each dimension will differ between search strategies for individual reviews. The themes of influences of search strategy design are a holistic configuration of high-level themes that could apply generally. The lower-level thematic influences of search strategy design support the establishment of the high-level themes, and are not intended to be a complete configuration of specific influences.

Chapter 3 Overview of current guidance and related literature on searching methods for systematic reviews

Sections 3.1 to 3.6 provide an overview of current guidance, evidence and debates on literature searching methods for systematic reviews, with specific consideration to diverse literature. I consider how this literature has developed and draw out influences and gaps in the methods of developing search strategies. This analysis aims to represent the range of subjects and themes in the literature; it is drawn from my knowledge from reviewing the literature for each of my publications on searching methods, additional reading and professional practice. Theoretical perspectives relating to systematic searching are discussed in Section 3.7. This literature was identified from searching bibliographic databases in library and information science (LISA, LISS and LISTA) and social science (Scopus and Social Sciences Citation Index) and browsing via the Google search engine, Google Scholar and the information science bookshelves in the UCL library. It also included searching three subject registers: the SRC methods library's searching subfile, the EPPI-Centre's database of searching methods and the Cochrane Methods Register. As linkages of information searching theories and searching for systematic reviews were not likely to be reported in journal abstracts, searches were also undertaken in the following databases that contain full-text journal articles in either library and information science or systematic review methods: ACM digital library, Europe PMC, PubMed Central, Wiley and Science Direct. The literature presented here is selective from these searches in order to address the research questions.

3.1 Sources of guidance used to inform search strategy methods

There is a variety of guidance on search strategy methods (Brunton et al. 2017, p104 (**SP1**)). Standards of conduct and methods used for systematic searching exist within particular research fields, such as health, education, environmental science, food safety, international development and software engineering in the form of guidance or handbooks. The Campbell Collaboration has published guidance on literature searching for reviews on education, social welfare, crime and justice and international development (Kugley et al. 2017). Armstrong et al. (2011) set out Cochrane Collaboration guidelines for reviews of health promotion and public health interventions. There are also standards for certain types of systematic reviews such as health technology assessments (EUnetHTA 2016). The University of York's Centre for Reviews and Dissemination (CRD) and the Cochrane Collaboration guidelines focus on reviews in healthcare (CRD 2009, Lefebvre et al. 2011). Guideline development organisations have standards for evidence reviews, such as England's NICE,

which spans clinical health, health systems, public health and social care (NICE 2014). The methodological guidance from the aforementioned organisations largely focuses on systematic reviews of effectiveness of interventions, though some also consider cost-effectiveness, qualitative evidence, and diagnostic test accuracy. Their standards are generally similar and they cite each other.

There are various standards of conduct and reporting within systematic reviews. The peer review of electronic search strategies (PRESS) checklist focuses on the execution of database search strategies of intervention reviews, and was developed to reduce errors and improve the selection of search terms through a peer review process (McGowan et al. 2016). The Cochrane Collaboration has methodological expectations on the conduct and reporting of intervention reviews (Higgins et al. 2016), including the searching stage. Gough (2013) observes there is an interlinkage of guidance with publication standards on reporting of systematic reviews and systems for appraising their quality. For example, there are currently no standards on undertaking meta-narrative and realist reviews, though there are publication standards on what should be reported (Gough 2013). Gough suggests there is "a richness of approaches to be used and developed" provided there is adherence to the "core principles of fitness for purpose, rigor in execution and transparency and completeness in reporting". This is consistent with the standards of the Cochrane and Campbell collaborations that require searches to be transparent, reproducible and accountable (Kugley et al. 2017, Lefebvre et al. 2011).

Other methodological guidance on searching can be found in books, for example, Petticrew and Roberts (2006), Cooper et al. (2009), Booth et al. (2012) and my co-authored book chapter (Brunton et al. 2017 (SP1)). These books focus beyond reviews of comparative effectiveness of interventions, and are cross-disciplinary, though generally use examples from health, education, social welfare and social science fields.

The guidance on planning a search strategy is generally limited to the rationale for searching, approaches to database selection, use of search filters, development of search terms and supplementary strategies, and structuring questions around comparative effectiveness questions. They vary in detail. The EUnetHTA guideline and Campbell Collaboration guideline are considerably detailed on the processes involved, and the Campbell Collaboration guide is supplemented by a 'methods note' on databases to search for international development intervention reviews, which often comprise diverse literature (Campbell Collaboration 2014). However, books and methodological reviews provide a more discursive exploration of methods across different types of reviews. All of these provide an overview of conceptual and practical considerations in developing a

search strategy, with slight differences in emphasis and detail. Brunton et al. (2017 (**SP1**)) particularly considers the principles, conceptual aims and approaches to searching methods, and draw on multi-disciplinary, policy-relevant systematic reviews that use a range of study designs as examples.

Practice is also informed from methodology-related reviews published in peer-reviewed journal articles or reports. Recent examples are: Booth's (2016) review on the search methods of qualitative systematic reviews; a review of literature search strategies for conducting knowledge-building and theory-generating qualitative systematic reviews (Finfgeld-Connett and Johnson 2013); methods of checking reference lists (Horsley et al. 2011); methods for searching for quasi-experimental studies (Glanville et al. 2017) and Sampson et al's (2011) review of search strategy precision in 94 healthcare systematic reviews.

There are two profession-specific collaborative initiatives which relate to the dissemination and appraisal of search methods, within the communities of information specialists involved in producing health technology assessments: one relates to producing health technology assessments (SuRe Info - Summarized Research in Information Retrieval for HTA), <http://vortal.htai.org/?q=sure-info>, and another on search filters (The InterTASC Information Specialists' Sub-Group Search Filters Resource, <https://sites.google.com/a/york.ac.uk/issg-search-filters-resource/home>).

Others have disseminated findings drawn from cross-sectional analyses, case studies or experiences of searching. My candidate publications fall within this category of studies. The studies within this category are numerous across the spectrum of systematic reviews and span various elements relating to designing search strategies. Selected examples of studies that explore sources and techniques for searching sources are: Wright et al. (2015) explore the utility of CINAHL for qualitative studies from an analysis of 43 reviews; Woodman et al. (2010) and Rathbone et al. (2016) analyse the utility of sources for identifying systematic reviews on specific topics; Booth et al. (2013) and O'Mara-Eves et al. (2014) report on novel techniques for capturing literature relating to complex interventions; and Boeker et al. (2013) and Bramer et al. (2013) examine strategies for searching Google Scholar.

3.2 Gaps in evidence

It seems that the current practice of designing search strategies is underpinned by generic guidance on searching processes, some empirical literature, and on practical experience. Information professionals need to use the best evidence available to them to inform their decisions; and the

evidence needs to fit the question and context (Brett 2016). The methodological guidance appears to have been developed from a consensus of professional opinion that draws on some research literature, though the formal procedures on developing the guidance are not clear from the guidance documents themselves. Lefebvre et al. (2013) state the Cochrane Handbook is revised in consultation within the information retrieval community within the Cochrane Collaboration. The Methodological Expectations for Cochrane Intervention Reviews (MECIR) standards of conduct and reporting have been refined from screening reviews and feedback from Cochrane members (MECIR nd). The EUnetHTA information retrieval guideline (2016) specifies it is based on empirical evidence published since 2000 and, where there is no evidence, it is based on experience of the guideline's authors and other information specialists. However, it is not clear how decisions on the evidence were made to inform the EUnetHTA guideline, and there is no indication that any quality and relevance criteria were applied to the evidence used to inform the process.

Overall there does not appear to have been a formal appraisal of the evidence-base for the much of the guidance. Exceptions are Booth (2016) and Glanville et al. (2017), who focus on specific study designs. Booth (2016) considers the strength of the evidence base in searching practice for qualitative evidence syntheses. Booth (2016) observes a paucity of good empirical literature on informing search strategies, which, by their nature, draw on diverse and diffuse literature. He observes that much current guidance stems from small research groups who cite each other, and is based on anecdotal best practice. Glanville et al. (2017) review evidence and guidance on identifying quasi-experimental studies and find a lack of evidence in structuring searches, which resources to search, and the consistency of the database indexing relating to study design, amongst others. However, there is an evidence base underpinning some methods, search filters have been critically appraised on InterTASC Information Specialists' Sub-Group Search Filters Resource, and some studies relating to searching methods for health technology assessments are critically appraised on SuRE Info.

EUnetHTA (2016) point to a lack of evidence of specific search methods on review findings in their guidance for effectiveness reviews. Hartling et al. (2016) comment that an important gap is "the modest amount of empirical evidence demonstrating the impact on results and conclusions from different approaches to searching"; this is in the context of searching for inclusion into Cochrane effectiveness reviews. Booth (2016), states that "rigorous evaluation would study whether items could have been identified using databases, regardless of how they were actually identified". Booth's review also observes "we have an imperfect knowledge of the most effective retrieval terms, partial understanding of the respective yield of different sources and, in particular, an incomplete insight of

the appropriateness of different sampling methods as they relate to different types of qualitative evidence synthesis." Because each literature search presents a unique challenge to working out ways of searching systematically and efficiently, there is inevitably imperfect knowledge of the efficient ways to search. However, research can help inform likely places to search, methods to use and limitations of approaches, depending on its relevance to a particular context.

3.3 Chronological perspectives on guidance and related standards

Considering the development of guidance from a chronological perspective is useful to understand their application to current practice. A comparison of the book chapter by White (1993) with its update sixteen years later (White 2009) provides an opportunity to explore shifts in methods for searching for research synthesis. Largely, the principles and procedures of searching for systematic reviews remain unchanged in both editions. However, the 2009 edition emphasises the influence of the Cochrane Collaboration in raising standards of searching and how searching has become more transparent. In 1993, White suggests that those undertaking the review should know their field and most of the studies, and recognises a reluctance to search bibliographic databases. In contrast, the 2009 edition observes the influence of Cochrane in making database searching an *expectation* rather than an ideal. The shift in database searching may also coincide with increase in new sources, stimulated by advances in technology and the internet (Grayson and Gomersall 2003). From reflecting on White's comments, perhaps the shift in database searching also relates to an increase in methodologists undertaking reviews who may not know the specific field in advance. For example, social policy-relevant reviews are undertaken at the EPPI-Centre by researchers with expertise in systematic reviewing, and need to draw on a range of fields and topic experts outside of their own knowledge.

Grayson and Gomersall (2003) report on a shift in UK Government policy-making since the 1990s towards using the best available evidence, leading to an increase in systematic reviews within social science. However, there was very little in the way of tools and strategies for conducting such research reviews and they drew on the clinical model which centre around "what works" questions Oakley (2017, p.xv). Booth et al. (2012 p.71) recognise the expansion of guidance of literature search methods which began from healthcare interventions, into social science, other areas and other types of study designs. Grayson and Gomersall (2003) observe that, in comparison with clinical systematic reviews, social science policy-relevant reviews have greater problems for literature searching. This includes more diverse literature, a wider range of bibliographical tools of varying coverage and quality and differences in terminology.

In recent years other approaches have been disseminated on searching for systematic reviews. Sandieson (2006) developed a system of 'pearl harvesting' to develop comprehensive synonyms that identify specific topics. In contrast, there is an increase in iterative, selective searching methods. Finfgeld-Connett and Johnson (2013) used a hermeneutic approach to searching described by Boell and Cecez-Kecmanovic (2010). This involves selective search terms to identify a small set of relevant literature, which is used for further targeted searches to locate additional literature. Booth et al. (2013) propose a set of systematic search procedures, described as 'CLUSTER searching', for undertaking iterative searching for a realist review. In realist reviews the type and focus of the literature sought can change throughout the review.

Grayson and Gomersall (2003) observe that new sources present a challenge if the aim of searching is for thoroughness. This point is echoed more recently by Wilkinson and colleagues (2016), who consider the increased production of scientific data sources for research generally. Lefebvre et al. (2013) predict in twenty years' time there will still be a need to identify new resources and researching efficient ways to use them. However, they expect the nature of these new resources may change. For example, resources may consist of datasets or use semantic analysis, which is based on the meaning of words and concepts, rather than the presence of these search terms.

Several authors anticipate future changes in designing search strategies as a result of using text mining procedures to semi-automate the screening of search results. These procedures reduce the time spent manually screening the same volume of studies, and may shift search performance to focusing on maximising the sensitivity of searches without being constrained by the precision of searches (McGowan et al. 2016, Lefebvre et al. 2013). This shift would require a re-conceptualisation of searching and screening, which are often considered separate activities. This itself, may not be problematic as though searching and screening involve distinct processes, they are actually on a continuum with the common aim of filtering out irrelevant literature in order to identify the most relevant (Brunton et al. 2017 **(SP1)**, Stansfield et al. 2016 **(CP5)**, Thomas et al. 2011). However, the shift towards highly sensitive searches, which could generate large volumes of irrelevant studies may be limited by the uncertainty surrounding the human resources needed to screen individual searches where precision is low, and by uncertainties on the methods and processes involved in implementing text mining (Stansfield et al. 2017 **(CP4)**, Stansfield et al. 2015, Thomas 2013).

Overall, there has been an expansion of searching for diverse literature and an increased reliance on information retrieval systems to identify it. Current methods and expectations of database searching have evolved beyond discipline-specific clinical effectiveness research, though the range of sources and diverse terminology mean this approach is particularly challenging for identifying diverse

literature. Iterative and selective approaches to searching are used by some researchers. Future technologies may both shift the nature of resources for searching and how these resources are searched. The chronological overview is useful in considering differences of approach in the next section.

3.4 Different approaches to searching in the guidance and related literature

There are two fundamental distinctions in the guidance and related literature on the purpose of searching. One view is that searching is necessary to reduce the publication bias introduced by the tendency of studies containing significant results to be published (Lefebvre et al. 2011). Another perspective is that searching is necessary to avoid missing relevant studies that offer different findings rather than collecting more of the same studies (White 2009, p57). Both reasons could be used as an argument for expansive, comprehensive searches. However, where the purpose is to find a range of studies to generate theory or explore themes or perspectives, the searches do not need to be comprehensive, and theoretically selective or purposive approaches are more appropriate (Brunton et al. 2017, p100 (**SP1**)). However, purposive approaches may be biased if, for example, perspectives of particular groups are unintentionally excluded through an approach to searching (Brunton et al. 2017, p102 (**SP1**)). Booth (2016) provides examples of searching for qualitative research and sets out different sampling options, depending on the types of review, and type of qualitative research being synthesised. However, Booth observes that, despite theoretical differences in sampling, the searches may not appear so different from one another in practice.

Another distinction between the guidance is that some require search strategies to be established *a priori* and other search strategies are developed iteratively. This perhaps relates to the study design, and the subject domain. Standards for reviews of effectiveness on clinical topics tend to promote comprehensive, *a priori* searches, whereas effectiveness reviews of diverse topics, such as education or social care may need *iterative* approaches in which "the terms that are initially used may be modified based on what has already been retrieved" (Kugley et al. 2017). For certain types of reviews, such as realist reviews, the types of literature required *emerges* through the course of undertaking the review. For example, the types of evidence required to test a theory underlying an intervention may evolve through the review (Brunton et al. 2017, p102 (**SP1**)). Therefore, the literature search is *iterative*. However, this second type of iteration is distinct from iterations to find the same types of studies, as it requires a change in the concepts searched for; it may be considered '*emergent*' (Gough and Thomas 2012 p60).

In summary, searching aims to locate either a comprehensive or a selective sample, the search concepts may be *a priori* or emergent, and the search strategy (relating to the resources and search terms) may be *a priori* (linear) or iterative. I describe the search strategy as 'linear' to avoid confusion in describing two elements as *a priori*. In terms of diverse literature, I consider that all these options could apply. This approach is implied in my co-authored book chapter (Brunton et al. 2017 (SP1)). Booth (2016) describes both search procedures and research questions as *a priori* or iterative, which largely map onto search concepts, resources and search terms. The other guidance does not conceptualise these three aspects of searching along these continuums. A possible explanation is that it does not attempt to distinguish differences of approach using these perspectives.

Despite differences of approach to searching, a general commonality across guidance and related literature is summarised in the following: "that decisions need to be made to balance the thoroughness of the search with efficiency in use of time and funds and the best way of achieving this balance is to be aware of, and try to minimize, the biases such as publication bias and language bias that can result from restricting searches in different ways" (Kugley et al. 2017).

3.5 Challenges of identifying diverse literature for reviews

The problem of finding diverse literature, even from database searches, seems to exist across domains. Problems arise from a lack of text words and indexing terms to differentiate studies of interest from other items in the database. The Cochrane Handbook observes that clinical randomised controlled trials can be difficult to retrieve where all the relevant records are available in MEDLINE, citing the work of Golder and et al. (2006) relating to studies of adverse effects and Whiting et al. (2008) studies of test accuracy (Lefebvre et al. 2011). The Cochrane Handbook also considers that non-randomised studies in the clinical domain are difficult to locate and an unbiased sample is the next best. Problems arise from poor descriptions in the titles or abstracts (Reeves et al. 2011). However, for research on social interventions, the literature is considered to be more diffuse and unreliably indexed than clinical topics (Kugley et al. 2017, Petticrew and Roberts 2006, p83). Booth (2016) lists 20 challenges to identifying qualitative research for inclusion in systematic reviews. These largely relate to the varied methodology and terminology, how they are presented in the titles, abstracts and database indexing, the range of publication media and resources they are indexed in, and the time involved. Other challenges are a lack of signposting from associated controlled trials (where present), and varying alignment of the focus of a primary study and the systematic review being undertaken.

Guidance tends to recommend use of a wider range of sources for complex interventions than for pharmaceutical studies (NICE 2014, CRD 2009). They also encourage Internet searching, scanning relevant organisational websites, reference checking to find relevant research published in books, book chapters, working papers, policy documents or departmental reports, and suggest considering handsearching of journals and citation tracking (CRD 2009). National and regional databases are important to access research not indexed elsewhere (Lefebvre et al. 2011). EUnetHTA (2016) consider there is a lack of evidence for searching national and regional databases, though acknowledges subject-specific databases are important. The Cochrane Handbook lists databases that are relevant to public health and health promotion. It observes that pragmatic decisions may need to be taken when balancing the time and other resources required in conducting comprehensive searches with the proportion of relevant to non-relevant studies identified. (Armstrong et al. 2011).

Searching to either find all relevant studies that exist or the most appropriate sample are both impossible tasks, as the extent of 'unknown public knowledge' is unknown (Swanson 1986). We highlight that exhaustive searching is a myth in our book chapter (Brunton et al. 2017, p98 **(SP1)**). White (2009, p61) points to confusion on this stating "one does hear of innocents who think that database or Web searches retrieve everything that exists on a topic". Booth (2006) points out "'good enough' is regarded as an acceptable substitute for the ideal ...[exhaustive search, though]...'good enough' is both subjective and elusive." The NICE Procedures Manual allows for "a flexible approach" to identify evidence "both systematically and in the most efficient manner"(NICE 2014, p77). However, the methods of searching not to miss important studies (either for comprehensive aggregation or for sufficient configuration), balanced with efficiency are unclear and therefore challenging to implement in practice.

Within the debate on searching for diffuse literature, there seems to be an argument promoting the searching less of the same types of sources, and more different sources. Booth (2010), argues against searching databases *ad infinitum*, and suggests that a better approach would be to search different types of literature. This approach seems particularly appealing where comprehensive searches yield volumes of citations that require too much resource to screen manually. Booth (2016) suggests searching a small number of key databases, some topic-specific and setting-specific sources and seeking non-journal literature, in the context of searching for qualitative studies. The evidence-base for this is unclear, though Morgan and colleagues have been exploring the evidence for this process through retrospective analysis of public health intervention reviews (Morgan et al. 2015). The role of supplementary searching is unclear in the current evidence. Wright et al. (2014) present a case study where citation searching did not identify additional studies for their review on multiple

risk behaviour interventions. Paisley (2015) considers that searching for complex interventions in public health is unsustainable using current procedures, and argues for a change of perspective and development of new methods.

In summary, designing search strategies involves judgements on how best to capture literature within the time and resources available. There is a tension between being efficient and sensitive in searching, but not missing important studies across all reviews. The challenges of searching are magnified for diverse literature in comparison with many focused clinical topics. There is appeal in searching less of the similar types of resources, and using a range of search techniques to search different types of resources, though the evidence base for searching is unclear. There are inevitable limitations in locating and accessing research, particularly where the research is fragmented or organised in ways that do not meet individual needs of the research (as highlighted in the opening quotes of Chapter 1). Exploring different dimensions of search strategy design and influences can inform on the variations, limitations and potential improvements of a search. In the following section I draw on the guidance and methods literature to discuss influences on designing search strategies.

3.6 Influences on search strategy design

Bates (2005, p12) observes that most social research in information studies centres around the "complex interplay" of information, information technology and people's use of these. Hjørland (2005, p.339-341) observes there is both a domain perspective on information seeking, where people who are part of a certain culture (or subject discipline) have norms on how they seek information, and also a socio-cognitive perspective, which relates to individuals' behaviour in seeking information, and their subjective knowledge. Therefore, in exploring influences of search strategy development, it I consider this in relation to technology, people and the processes required as being part of the domain or culture of systematic searching. Table 3.1 summarises some influences on searching that are drawn from the considering the guidance and related literature, and is further described in the text below.

Table 3.1 Some influences on searching drawn from the overview of the literature

	People	Processes
People	<ul style="list-style-type: none"> Information specialist being integral to the review team 	<ul style="list-style-type: none"> Peer review Motivation, standards and expectations Filters and published evidence
Technology	<ul style="list-style-type: none"> Identifying search terms – text mining/other processes Identifying literature from specific resources Adoption of technology 	
		<ul style="list-style-type: none"> Text mining to facilitate searching and screening Information overload, and low precision searches Databases versus supplementary sources
Overarching themes	<ul style="list-style-type: none"> Information sought Research environment 	

3.6.1 People

The information required is expected to be specific to review questions or types of review, and these distinctions have already been considered above; certain study designs and domains of literature may be more identifiable than others. In terms of people, EUnetHTA (2016) stresses the importance of an information specialist being integral to the review team to improve the quality of the search.

3.6.2 People and processes

At the interface of people and processes, drawing on White (1993, 2009), motivation and expectations appear to be influential in the choice and extent of searching. White (2009) recognises the influence of the Cochrane Collaboration in increasing the use of bibliographic databases, and the reporting of search strategies. A second example is that peer-review of search strategies through an advisory group or information professional is often an expectation of guidance. The PRESS checklist was developed in order to influence the quality of searches (McGowan et al. 2016).

3.6.3 People and technology

There are also influences on the boundary between people and technology. Utilising databases and online resources with different functionalities for retrieving research is an important aspect of a typical systematic review. Text-mining and machine learning offer the opportunity for both search term development and automation of screening and feasibility of obtaining searches of high volumes. Section 3.3 highlights that there are conceptual shifts and uncertainties involved in

adopting new technologies. EUnetHTA (2016) describes two different approaches to search strategy development, the conceptual approach, which uses a variety of sources and literature to develop search terms, and the 'objective approach', which relies on text mining to develop topic search terms. Ongoing advances in technology affect how literature is organized, identified and displayed, and potentially provide challenges and opportunities for the identification of literature.

3.6.4 Processes and technology

In terms of process, the processes yielding high volumes of irrelevant records are being challenged through questioning the need for, and the efficiency of, comprehensive searching, and proposing increased reliance on supplementary searching. A separate issue is that supplementary searching is often posited from the perspective of finding unpublished studies, or for studies published in formats outside databases. However, given that even sensitive database searches cannot always retrieve everything within a database (as described above on 'challenges of identifying diverse literature'), I suggest a third reason for supplementary searching is also important to mitigate the deficiencies of database searching (Stansfield et al. 2016 (CP5); Stansfield and Liabo 2017 (CP3)).

3.6.5 Overarching themes

Clearly, the nature of the information sought is an overarching theme. It also seems logical that the environment of research, the researchers, and the opportunities influence the search approach and strategy taken. Two contrasting approaches by different research teams towards processing high volumes of literature on broad topics are illustrated in the following examples. Shemilt et al. (2014) describe a case of 'extreme reviewing', using text mining to prioritise the references that were manually screened for two scoping reviews where the literature searches collected over 800,000 records. These reviews had ill-defined boundaries relating to behaviour change interventions. In contrast, a review on whole-systems approaches to obesity (Garside et al. 2010) was undertaken iteratively to build a series of results at each stage as the scope of whole system approaches was ill-defined (Levy et al. 2015).

The brief appraisal of the literature on guidance and related documents in sections 3.1 to 3.6 is influenced by my own stance of searching for reviews beyond the effectiveness of interventions, in cross-disciplinary topics, social science, social care, public health reviews. The findings are drawn on in each of the remaining chapters in order to address my research questions. Firstly, I consider some theoretical perspectives on systematic literature searching.

3.7 Theoretical perspectives on systematic literature searching

Literature searching relates to how knowledge and information is disseminated and organised within a domain, information storage and retrieval systems, and the information literacy and behaviours of those seeking information. From a search of the literature I observe there is a wide and large literature on information searching theories, and a small literature linking some of these theories with literature search methods used in systematic reviews.

3.7.1 Models of systematic literature searching

There are many theoretical models that have been developed to explore and describe information seeking behaviour, information searching and information retrieval, with a correspondingly wide range of discourse on best practice. They range in terms of their philosophical and theoretical and methodological focus (Bates 2005, Case and Given 2016). Dinet and colleagues (2012) and Xie (2012) each review models on information searching in computer systems. Dinet and colleagues (2012) emphasise the cognitive activities and Xie (2012) largely relates to processes, though the two reviews draw on both of these aspects. These reviews demonstrate that information searching is a complex activity comprising many actions and thought processes. Dinet et al. (2012) conclude that information searching is a complex activity involving individual (cognitive, affective), contextual and social factors. Xie (2012) describes different 'levels' of information searching and factors relating to searching. For example, Xie (2012) observes that searching on one level is a series of 'search tactics', which involves formulating searches and search terms. Another level is the 'search strategy', which encompasses a range of aspects including, developing conceptual sets of search terms, approaches to using different information retrieval system features, or modes of interaction with an information retrieval system, like searching and browsing (Xie 2012). Factors relating to searching include: the task, user knowledge, the design of information retrieval systems, and the social and organisational context influencing the search process (Xie 2012). It is my understanding that while the plethora of information searching models describe different processes, cognitive activities and influencing factors, these models do not capture the specific processes and factors relating to the design of search strategies for systematic reviews.

An extensive literature search identified four theoretical models related to systematic literature searching developed from empirical research (Merz and Knüttel 2015, Hung et al. 2008, Sundin 2008, Zins 2000). Sundin (2008) is informative on the different ways systematic searching might be conceptualised. The other three models relate to procedures, though they differ in their approach. It seems there is no model describing the overall approach to search strategy design.

Sundin (2008) developed four different perspectives of teaching information literacy and systematic searching, which comprise: 1) a source approach, where sources of information are considered by their subject; 2) a communication approach, which considers the way information is produced in different contexts; 3) a behaviour approach to searching individual repositories of information; and 4) a process approach from research question to collecting the required information.

Hung et al. (2008) describe information seeking as a "complex problem-solving activity" and Zins (2000) discusses the role of creativity in the systematic process. Zins (2000) explored how creativity in the systematic process could be formalised as part of a larger project of verifying a systematic model of searching procedures through a Delphi survey with fifteen information specialists. Although creativity was acknowledged as part of the process, how it is incorporated in the systematic searching process was unresolved. Zins considers that by being systematic studies will inevitably missed, and cites Godel's 1931 Incompleteness Theorem, that being systematic is a theoretical impossibility. Zins concludes that "it is impossible to formulate a search strategy that can meet all the information needs of the searcher without utilising non-systematic solutions (i.e. spontaneous, creative and accidental)". I presume the basis of this reasoning is that it is impossible to specify in advance information that is sought but not yet known.

In the three procedure-based models (Merz and Knüttel 2015, Hung et al. 2008, Zins 2000), there is a final step in the search which is a verification or evaluation stage. At this stage one reflects on the information collected, or the search terms and strategy used, and decides whether the process is sufficient, or to continue searching. This theoretical cyclical process poses a problem for systematic reviews undertaken in a 'linear mode', as search results may take many weeks or months to evaluate prior to establishing a set of included studies, and re-iterations of the full systematic search are not a norm or expectation of the process. This has been addressed in different ways by the systematic searching models. In Merz and Knüttel (2015) the process of validating and evaluation are two separate activities, though this conference poster does not elaborate this in detail. In Zins's model, the evaluation should consider the four criteria: reliability, validity, relevancy, and sufficiency (Zins 2000). Hung et al. (2008) describe a last stage as "assessment" and observe this is undertaken with varying detail depending on the time cost, what is required of the search strategy, and the stage of the search. Clearly verification or assessment is a distinct step, though the utility and extent of verification for designing search strategies appears variable. In considering designing search strategies for diverse literature, this is particularly challenging as what is not known may remain unknown.

There is a small literature linking some information searching models with literature search methods used in systematic reviews. Bates' berrypicking model (Bates 1989) seems to be particularly quoted by a number of researchers. A brief description of the berrypicking model is that it consists of four characteristics: 1) the user's query evolves; 2) searching is a dynamic process of finding 'berries' instead of one retrieved set; 3) a range of types of searches are used which shift during the process (e.g. database searching, citation searching, author searches, among others); and 4) resources used are in different formats and content (Bates 1989, Xie 2012). It is interesting to note that in the methods literature for systematic reviews, berrypicking procedures seem to apply across the spectrum of those aiming for comprehensive searching and those aiming to be more selective. For example, Barroso et al. (2003) describe using multiple types of searching to identify qualitative research comprehensively including citation searching, journal handsearching and scanning library bookshelves. In contrast Finfgeld-Connett and Johnson (2013) describe using berrypicking for undertaking selective searching. Indeed Bates' concept of berrypicking is that there is no definitive set of references (Bates 1989). Booth et al. (2013) implement berrypicking in a way that aims for greater completeness for identifying literature in greater depth on selected areas (or clusters of related research), whilst employing systematic procedures. Paisley (2015) considers that the binary nature of Boolean searching is inadequate for capturing literature on context that is important for understanding and comparing complex interventions in public health, and speculates that systematic searching should consider other information retrieval models, though these methods are not yet developed. Overall, it seems a key benefit of berrypicking is the broadening of constraints imposed by a topic-based Boolean search based on specific concepts, in order to mitigate against pre-conceived ideas. There is a potential limitation that it may be perpetuating citation practices and careful consideration on the types of literature being drawn on is suggested (Briscoe 2016, interpreting Hjørland 2002). The fact that there is no definitive set of references within the berrypicking approach does not appear to be discussed in the systematic reviews literature on searching, but the techniques of berrypicking appear to have been adopted in order to enhance or mitigate limitations from topic-based Boolean searches. Berrypicking appears an option to counter lexical and location diffuseness of the literature, or describe searching for reviews where the research question develops in an emergent fashion. However, it is not a sure means of providing a representative or wider selection of the published research than may be found otherwise.

3.7.2 Systems for searching

Historically, document information retrieval (IR) systems have been developed to help overcome information overload faced by users when searching for documented information to solve an

information need (Frants et al. 1997). Frants et al. (1997) describe difficulties by users in articulating an information need into a search that provides the information sought. One solution has been to develop systems that interpret the user's search to provide documents it considers are the most likely match (best match searching). Such systems tend to privilege high precision over high recall (sensitivity) of all pertinent information. This has both opportunities and challenges for diverse literature; whether information is central or marginal to a domain may influence relevance judgements and retrieval (Palmer and Fenlon 2017). In contrast, the information retrieval systems largely relied upon for systematic reviews tend to privilege high recall over high precision. They tend to involve Boolean-based user-designed search queries to locate all documents that exactly match the query (exact match searching), and often results in identifying large volumes of unwanted documents. Hjørland (2015, p1569) suggests there is no evidence that other information retrieval methods are better than Boolean searching by skilled users, though suggests there are areas needed for improvement in both theory and practice. Karimi et al. (2010) evaluated Boolean searching and ranked retrieval for a series of biomedical systematic searching tasks. They found that for high-recall searches the Boolean searching had better performance than ranked retrieval.

The relationships between terms and phrases that express the same idea or meaning is a fundamental consideration in how information systems represent documents and process user queries, and in how users formulate searches. Examples of lexical relationships are: similarity (*car* and *automobile*); meronymy, or part relationships (*car* and *wheel*); antonymy, or adjective relations (*hot* and *cold*); pertainyms, adjective-noun relations (*crime* and *criminal*); hyponyms, or hierarchical relations (*finger*, *hand*, *arm*) (WordNet[nd], Budanitsky and Hirst 2006, Fellbaum 2006). Some words have multiple meanings, and their use in conjunction with other words provides context on their meaning, for example the term '*bank*' is given different contexts by the terms '*money*' or '*river*' (Budanitsky and Hirst, 2006). Budanitsky and Hirst (2006) consider that there are many variations that go beyond lexical variation, such as functional relations or frequent associations; for example, the related phenomena of '*rain*' and '*flood*', or the related objects of '*pencil*' and '*paper*'. Blair observes there is no limit to the number of different ways words, phrases and sentences can be used to express the same idea or meaning (Blair 1990, p122) and argues that representing documents is a linguistic process and any indexing philosophy or automatic indexing procedure presupposes a theory of meaning in language (Blair 1990, p169). Knowledge is organised in different ways, for example as user-based, facet-analytical or domain-analytical viewpoints, according to an understanding of documents, genres, discourse, epistemologies and domains (Hjørland (2015). However, in terms of user database searching, Fidel (1991a) observes that sometimes terms can discriminate between relevant and irrelevant documents in a way that is pragmatic, in that it

depends on the terminology used in the searched text within the context of a database rather than based on linguistic or philosophical theories. In this way a term might be useful in one database and not be useful in another.

The representation of documents and their retrieval has implications in terms of the time taken, as expressed by Warner's labour theoretic approach (Warner 2008). Warner describes the work in document representation as 'descriptive labour' and in retrieval as 'search labour', and some of the elements can be automated and while other processes require human interpretation (Warner 2008). System design can both frustrate and assist document retrieval (Warner 2007). For example, a lack of description, or the use of descriptions that are not helpful to the user means that the work involved in searching is increased (Warner 2008). Furthermore, if there is a wider availability of resources, it would increase the selection labour (Warner 2008). In the context of systematic reviews, areas for human interpretation include description labour by indexers and search labour by retrieval experts for systematic reviews (Urquhart 2011). While some automation is possible, literature searches in healthcare areas where the terminology is diffuse have low precision to achieve high recall (Sampson et al. 2011). However, Urquhart (2011) observes there are things that technology can do that are more difficult for humans, such as related item search algorithms. Such a function could be considered a form of description power (Sampson et al. 2011).

Hjørland (2015) suggests a close connection between Boolean search systems, the need for experienced human searchers and developing knowledge concerning optimal search strategies and information literacy. In describing classical Boolean searching of a database, Hjørland (2015) observes that the efficiency of the search is dependent on two aspects: the quality of the bibliographical records, their indexing, metadata, and relevant discriminatory power (*objective search possibilities*); and the qualifications of the searcher (the *subjective search possibilities*). Such 'objective search possibilities' may be influenced by a variety of factors relating to the information retrieval system. For example, Lancaster and Warner (1993, p206) list 14 qualitative aspects of databases, under three categories of database coverage, time and indexing and vocabulary factors, as follows:

- 1) Coverage factors: number of sources, types of sources, number of items, time span, completeness in relation to user needs, uniqueness and overlap;
- 2) time factors: time lag, frequency of update;

3) indexing and vocabulary factors: degree of vocabulary control, specificity of the vocabulary, searching aids provided, semantic and syntactic ambiguity, exhaustivity (number and variety of access points), accuracy and consistency (observed error).

In considering the '*subjective search possibilities* ', the connection with Boolean search systems and searchers is well-established in information retrieval literature. According to Lancaster and Warner (1993, p158), the quality of search strategy depends on its "adequacy and accuracy, which is based on four factors, the user's ability to select terms that: 1) represent the subject sought; 2) are arranged logically; 3) represent all reasonable approaches to retrieval; and 4) are constructed in a way to achieve the level of recall and precision required. Harter and Peters (1985) describe information retrieval in terms of 'heuristics', suggesting tentative general actions, tactics and behaviours that *may* produce useful results. They argue these are not algorithmic rules that can be mechanically applied.

3.7.3 Perspectives on user searching

Iivonen and Sonnenwald (1998) present a model on search term selection, consisting of six different ways in which professional searchers report how they search, including controlled vocabulary, indexing, and previous experience. Their analysis demonstrates that there are multiple sources of search terms and selecting search terms is a complex and varied process among searchers. Fidel observed the behaviours and actions of professional searchers (Fidel 1984, 1991a, 1991b, 1991c). Fidel suggests that the selection of search terms is influenced by a combination of terminological conditions, the characteristics of the search request, the availability and quality of databases and thesauri, and searcher behaviours. Some individual characteristics of searchers are part of a person's searching style, some inherent and some are acquired from professional experience (Fidel 1991c). Fidel identified two types of searches: operations and conceptual, where operations searches are actions to modify searches within a system, without altering the meanings of a search, and conceptual searches are actions that modify meanings or concepts. While searchers freely broadened conceptual meaning to increase recall, they avoided conceptual modifications for attaining higher precision, and used operational actions instead (Fidel 1991c). However, Fidel considers that searchers favour operational or conceptual approaches and some are more active than others in modifying search strategies and using more search terms than others (Fidel 1991c).

Acquiring expertise in searching in terms of 'threshold concepts' has been examined by Tucker (2014). Threshold concepts are theoretical constructs describing a 'learning barrier' and they "represent a transformed way of understanding, or interpreting, or viewing something without

which the learner cannot progress" (Meyer and Land 2003). These concepts are likely to exhibit certain characteristics, which are described by Meyer and Land (2003): they cause a "shift the perception of a subject"; are "unlikely to unlearned"; reveal the interrelatedness of something; are sometimes conceptually bounded; and are potentially problematic for learners to understand. Tucker (2014) proposes four threshold concepts in acquiring search expertise following research that involved interviewing and task-observations of both experienced and student searchers. These concepts comprise: 1) discerning and applying an understanding of the information environment; 2) understanding information representation, such as document structures, index structures and retrieval algorithms, and separating the concepts of an information need; 3) information vocabularies such fluency in searching using free-text, controlled vocabulary, proximity, truncation and other language-based tools (Tucker et al. 2014), including learning to consider synonyms; and 4) an integration of the first three concepts in a way that is likened to that of a jazz musician who knows the tools and then improvises within the structures (Tucker 2014). Tucker et al. (2014) found that prominent traits of expert searchers are: "extreme perseverance, curiosity and a combination of being willing to adventure, enjoy the hunt and knowing when to stop".

Each of the perspectives on user searching and the notion of creativity reported by Zins (2000) could support consideration of user searching in terms of "design thinking". Design thinking relates to a way of thinking about solutions for problems that are situated within a real-world context (Shute et al. 2017). There are a variety of perspectives on the nature and processes of design thinking, which are reviewed by Razzouk and Shute (2012). Common features consist of 1) locating and using resources to specify the problem and generate ideas; 2) and iterative process of creating and synthesising solutions, and 3) testing and evaluating solutions. It involves both cognitive processes and traits of persistence and creativity, and building experience in a particular domain allows designers to quickly identify a problem and propose a solution, and help adjust to unexpected changes (Razzouk and Shute 2012).

3.7.3 Summary

In summary, literature searching for systematic reviews is a complex activity involving strategic interactions with information retrieval systems. The process of being systematic generally means following set procedures, though addressing the challenges relating to individual tasks involves problem-solving and creative approaches. The meanings and ideas described by diverse language pose challenges for the representation of items in an information system and the retrieval by users, and the time and resources available for searching. The systems themselves vary, and while a variety

of systems may help target relevant literature, the underlying structures for storing information and functions of searching are not transparent. Even 'objective' aspects of scholarly bibliographic databases, which relate to how information organised and the structure and functions of the system, are not fully transparent, as each database varies in terms of coverage, timeframe and indexing. Boolean-based database searching is currently a mainstay of systematic reviews in that it provides user-control, a level of transparency and effective method of searching. However, it poses problems in terms of high volumes of results, and it relies on the subjective queries by the user. Verification of searches can never be fully addressed. There is a need for users to be both systematic and use a creative problem-solving approach, and there are potentially certain skills, traits and expertise that may aid success. Boolean concept-based searching may be limited for diverse literature and for systematic reviews that draw on a range of different literatures and contexts. Berrypicking is cited for multiple approaches to searching, and for both comprehensive and selective searching. However, its selective approach may pose conceptual problems where it is relied upon to provide a representative sample of studies for a systematic review.

Chapter 4 Characterising 'diverse literature' in relation to search methods for systematic reviews

This chapter characterises aspects of 'diverse literature' in relation to search methods for systematic reviews. 'Diverse literature' does not appear to have been defined elsewhere in the literature. I develop the thematic categories and dimensions of search strategy design shown in Figure 4.1 from analysing the design of ten search strategies. These categories and dimensions enable an examination of how search strategies for diverse literature can vary and aids analysis of the range of challenges involved in developing search strategies.

Figure 4.1 Thematic categories and ten dimensions of search strategy design

Thematic category	Dimension	Range	
Domain and publishing norms	Subject domains	Multiple	Single
	Dissemination	Diffuse	Narrow
	Search resource types	Multiple	Single
Research questions and scope	Search sample	Comprehensive	Selective
	Establishing search concepts	Emergent	<i>A priori</i>
	Meanings of search concepts	Multiple	Single
	Searching strategy	Iterative	Linear
Terminology	Search term diversity	Wide	Precise
Information organisation	Indexing	Broad	Specific
	Discriminating power of search	Low	High

This chapter describes how the thematic categories and dimensions were developed, followed by a description of each element and the aspects that may characterise diverse literature. I use this to position how my candidate publications and current guidance address designing search strategies for diverse literature. Influences that affect decisions on specific dimensions are described in Chapter 5. Both the dimensions and the influences are incorporated into the model of search strategy design, presented in Chapters 2 and 6.

4.1 Developing the ten dimensions of searching and thematic categories

A two-step process was taken to compare the systematic search strategies of ten reviews in which I took a lead role in designing. These reviews were selected for their potential in capturing a range of themes around the challenges of designing search strategies. The aim was to configure a variety of themes rather than counting (or aggregating) similar themes. The text of the review reports were analysed, though for the unpublished reviews the final draft report submitted to the funder was used, and for Jerrim et al. (in process), the review protocol and brief report on the search was used (dated 3 February 2016).

Step 1: Firstly, the reviews were analysed using the dimensions of difference framework developed by Gough et al. (Gough et al. 2012, Gough and Thomas 2012, p35-66) and described in Figure 4.2. The findings from this analysis are described in Table A1 of Appendix 3. Initially, I anticipated that this framework could help characterise diverse literature. However, this approach did not fully reveal the different challenges relating to searching within the ten reviews. On reflection, this is unsurprising as the dimensions of difference framework are intended to describe variation between reviews (Gough et al. 2012). Analysing the reviews using the dimensions of searching (Gough and Thomas 2012) was useful for comparing the extent of the searches but this did not help distinguish the variety of challenges encountered with diverse literature. For example, the following dimensions do not characterise the nature of literature sought, but could describe variation between some reviews: nature of sufficiency of search; the use of specific search sources; and the extent of the search. Therefore, additional dimensions were needed.

Figure 4.2 Dimensions of difference of systematic reviews and search strategies. Adapted from Gough et al. 2012, and Gough and Thomas 2012, p35-66.

Systematic reviews: dimensions of difference

1. Review aims and approach
 - i. Approach: Ontological, theoretical and ideological assumptions
 - ii. Type of answer sought from a review question
 - iii. Nature of synthesis: not a synthesis (descriptive)/ aggregative/ configurative
2. Structure and components
 - iv. Map and synthesis components (Single stage/ multiple stages/ mixed method syntheses)
 - v. Relation between these components
3. Breadth, depth, work done by reviews
 - vi. Macro-research strategy (e.g. breadth/depth of questions for map and/or synthesis)
 - vii. Resources used to achieve this: adequate/rapid/scoping

Search strategies: dimensions of difference

- viii. Nature of sufficiency: sufficient aggregation/configuration/emergent
- ix. Search sources: hard copies/electronic databases/web search engines/web pages/ personal recommendations/ items referred to in materials already found
- x. Extent of search: range of sources
- xi. Extent of search: comprehensiveness of search terms
- xii. Extent of search: time investment

Step 2: From considering the original dimensions of searching, I identified four additional themes to analyse each review. The following four themes were used to compare the ten reviews:

- Rating the selection process of search sources (easy to difficult);
- Judging the relative complexity of search terms to develop (simple to challenging) and reflecting why;
- Estimating the size of irrelevant literature potentially located from using the search concepts (small to large); and,
- Observing agencies or approaches used to help address challenges of search strategy design.

The first three themes are relative concepts, but facilitate analysis of important distinctions between the ten reviews. The difficulty in selecting search sources was informed by reflecting on: the range of sources; types of sources; and the multiple subjects covered. Two dimensions emerged from considering the degree of 'complexity of search terms to develop' and reasons why: search term diversity, and meanings of search concepts. Estimating the size of irrelevant literature potentially located from using the search concepts prompted consideration on the reasons why this was the case. Observing the agents and approaches used to help address challenges of search strategy

design generated data that are separate to characterising the distinct aspects of search strategy design. These are considered as influences on decision-making surrounding particular elements of search strategy design and are described separately in Chapter 5. The elements that emerged from this analysis were configured into distinct dimensions and categories that could potentially describe the specific elements of designing search strategies in general. In developing and refining the dimensions, although the data emerged from the sample of ten reviews, the interpretation was also informed by my knowledge of the literature, my findings from my candidate publications and experience of developing search strategies.

4.2 Description of the sample of the ten reviews

The sample of the ten reviews is described in Table 4.1 by subject domain and focus. The reviews differ in terms of subject domain and focus; they cover public health, social care, social science, health and education topics. All ten reviews use a systematic approach to searching, though three of these are not categorised as EPPI-Centre 'systematic reviews'; one is described as a literature review (Gough et al. 2014), another was a review of all research on specific topic areas that utilised Millennium Cohort Study data (Kneale et al. 2016), and one is a collection of evidence reviews utilising a single search strategy to inform development of a NICE guideline (NICE 2016). Appendix 3 describes the sample in further detail.

Table 4.1 Ten reviews used in the sample, described by topic area and focus

Review #	Topic area	Focus	Reference
1	Public Health	Views of obesity	Rees et al. (2009)
2	Public Health/Health Systems	Public health role of community pharmacies	Stokes et al. (in press)
3	Social Science	Social values	Gough et al. (2014)
4	Health and social care systems	Transition from child to adult health services	NICE (2016)
5	Healthcare	Osteoarthritis and exercise	Hurley et al. (in press)
6	Healthcare	Cosmetic interventions	Brunton et al. (2013)
7	Public Health/Health Systems	Self-care of minor ailments	Richardson et al. (in press)
8	Education	Performance differences: paper and computer testing	Jerrim et al. (in process)
9	Public Health	Population mental health	Rees et al. (2016)
10	Social Science	Under-use of data from the Millennium Cohort Study	Kneale et al. (2016)

4.3 Findings

Table 4.2 shows how the elements emerging from the analysis were translated into dimensions and subsequently grouped into categories. The examples were selected across the ten reviews to illustrate each of the elements. Table A2 of Appendix 3 and accompanying description provides detail on the themes that emerged during thematic analysis for each review, which were used to develop Table 4.2

Table 4.2 Development of elements into dimensions and categories

Element	Dimension	Category	Example from a review
Publication formats	Dissemination	Domain and publishing norms	Concern that "surveys conducted at a local level may not have been published in journals" (#9)
	Resource types		
Multiple subjects	Subject Domains	Domain and publishing norms	Education review searched social science and information science, education databases (#8)
Full-text search	Resource types	Domain and publishing norms	Test searches revealed some citations would only be found through full-text searching (#10)
Nature of title, abstract or indexing	Resource types	Domain and publishing norms	Journal hand searching and searching reference lists and undertaking citation searches of relevant systematic reviews (#6)
	Indexing	Information organisation	Research involving minority ethnic groups within larger populations was expected to be hidden from the title, abstract, indexing (#9) Used a range of index terms relating to social values (#3) PsycINFO index field for diagnostic instruments used (#9)
Sector diffuseness	Subject domains	Domain and publishing norms	Service transitions in social care: websites in education, social care and health settings were searched (#4)
	Meaning of search concepts	Research question and scope	Continuing care and service transitions social care and healthcare services (#4)
Diffuse concepts	Meanings of search concepts	Research question and scope	Concept of self-care: supported or independent range of actions were five sub-concepts (Self-care; help-seeking behaviours; self-care support services; utilising general practice or utilising urgent care (#7)
Multiple stages of search	Searching strategy	Research question and scope	Systematic search to define search concept of 'minor ailments' (#7)
	Establishing search concepts		Re-conceptualising search concepts to supplement the original strategy (#9)
Establishing search concepts	Nature of sufficiency	Research question and scope	Familiarisation to inform search concepts (#3); A selective search generated a large number of themes (#3)
Search sample			
Different types of sources	Resource types	Research question and scope	Journal hand searching and searching reference lists and undertaking citation searches of relevant systematic reviews (#6)

Element	Dimension	Category	Example from a review
Selecting resources	Resource types	Research question and scope	Advisory group member suggested additional databases (#1)
Updating other reviews	Searching strategy	Research question and scope	Updated the searches of systematic reviews, to utilise reviews and increase precision of overall search (#9)
	Precision	Discriminating power of search	
Increasing precision	Discriminating power of search	Information organisation	Excluding concepts such as hospitalized (#2)
High sensitivity	Discriminating power of search	Information organisation	A comprehensive range of search terms were used (#7)
Sensitivity versus implications for screening	Discriminating power of search	Information organisation	A simple sensitive search meant that two stages of screening were needed (#10)
Terminology simple	Search term diversity	Terminology	Database search uses a distinct name (Millennium Cohort Study), and only a few variants of this phrase required (#10)
Terminology diffuse	Search term diversity	Terminology	Knee osteoarthritis described as gonarthrosis, chronic knee pain, musculoskeletal pain in knee, arthralgia, arthritis (#5)
	Search operators	Information organisation	Proximity word searches used to describe transition programmes, services, schemes (#4)

4.4 Discussion: Describing the dimensions of search strategy design and thematic categories

The resulting thematic categories and dimensions collectively characterise search strategy design. Each dimension has characteristics that are on a continuum. These are presented in Figure 4.1 and they demonstrate a range across each dimension. The difference between two searches could theoretically be compared using the characteristics of each dimension. The characteristics are relative concepts; it is not intended to formulate precise definitions of them. The labels were chosen to describe a dimension succinctly and to avoid labels that may have other established interpretations. However, there appears to be a lack of vocabulary to describe aspects of searching such as 'establishing search concepts' and 'meanings of search concepts'. Each category and their dimensions is described below.

4.4.1 Domain and publishing norms

There are three dimensions of search strategy design that relate to domain and publishing norms. Firstly, the range of subject domains within a review may be single or multiple. Secondly, how the literature is disseminated may be predominantly through one type of media or many, such as books, journal articles, standalone reports, or working papers. Thirdly, the range of search resource types in which relevant literature is identified from may be one type (such as databases) or scattered across databases, websites or specific repositories. Although the three aspects are related, their distinctiveness enables the possible variations for different reviews to be reflected.

4.4.2 Research questions and scope

There are four dimensions of searching relevant to the research questions and the scope. Firstly, sample sufficiency is the extent to which the search sample is intended to be selective or comprehensive. Secondly, establishing search concepts is either *a priori* or in an emergent fashion. Thirdly, a related dimension is whether the searching strategy is linear or iterative. If the search concepts are developed emergently, it follows that the searching strategy is iterative. However, it is also possible that the search concepts are established *a priori*, but the searching could be iterative, so these are considered separate dimensions. The fourth dimension, meanings of search concepts, shows that search concepts have single or multiple sets of meanings. The meanings depend on the broad or narrow scope of a research question. For example, in review #7, the scope of the research questions on self-care for minor ailments encompass 'self-care' across a range of independent and supported actions. The search concept 'self-care' has multiple meanings across five areas: 1)

independent self-care (e.g. self-medicating, resting at home); 2) help-seeking behaviours; 3) utilising self-care support services; 4) utilising general practice; or 5) utilising urgent care. The first two dimensions reflect the ontological, theoretical and ideological assumptions of a review. All of four dimensions relate to the research questions and scope of the review.

4.4.3 Terminology and information organisation

Search term diversity is distinct from conceptual meanings of search concepts, as diverse terminology may describe the same entity. For example, in review #5 'knee osteoarthritis' is also described in at least five other ways: gonarthrosis, chronic knee pain, musculoskeletal pain in knee, arthralgia in the knee and arthritis in the knee. This grouping is context-specific, and while these terms were perceived to be synonymous within the context of this review, they may not be synonymous within other contexts.

The information organisation category relates to the distinctiveness of the search terms used within a search strategy to distinguish relevant research from irrelevant research based on the organisation of the information, and the searching functions available to the user. Information organisation may be reflected in the database indexing, which is the first dimension. The second dimension relates to the discriminating power of the search, which encompasses recall (sensitivity) and precision, and may relate to the use of search operators, from simple Boolean functions to more complex proximity searches.

4.5 Using the dimensions and categories to characterise diverse literature

Figure 4.3 shows the same categories and dimensions from Figure 4.1, though they are described in relation to diverse literature. The left side typifies more diverse literature, particularly for seven out of ten dimensions. The right side typifies characteristics of more homogenous literature. However, individual search strategies for diverse literature may vary along these scales, with some dimensions being similar to those for homogenous literature. The seven dimensions that appear distinctive to diverse literature: subject domains, dissemination, resource types, meanings of search concepts, search term diversity, indexing, and discriminating power of search. The characteristics of the remaining three dimensions (search sample, establishing search concepts, searching strategy) are common to all literature (i.e. where they are on the scale of each dimension does not distinguish between diverse and homogenous literature). They are influenced by the scope of the review. In the sample of ten reviews most reviews attempted to be comprehensive, the search concepts were

largely developed *a priori* and the searching strategy was generally linear. However, these three dimensions represent fundamental variations in the approaches to literature searching.

Figure 4.3 Thematic categories and dimensions for diverse literature

Thematic category	Dimension	Diverse	Homogenous
Domain and publishing norms	Subject domains	Multiple	Single
	Dissemination	Diffuse	Narrow
	Search resource types	Multiple	Single
Research questions and scope	Meanings of search concepts	Multiple	Single
Terminology	Search term diversity	Wide	Precise
Information organisation	Indexing	Broad	Specific
	Discriminating power of search	Low	High
The following dimensions do not necessarily typify diverse literature:			
Research questions and scope	Search sample	Comprehensive	Selective
	Establishing search concepts	Emergent	<i>A priori</i>
	Searching strategy	Iterative	Linear

The purpose of thinking about the search strategy in terms of dimensions is to explore what is challenging about search strategy design for diverse literature and reflect the range of possibilities that may exist for individual reviews. For example, the aim of review #10 was to identify all the research that used particular data from the Millennium Cohort Study. The search used a simple set of search terms to describe the Millennium Cohort Study. Test searches indicated this set of search terms had a high discriminating power to distinguish between relevant and irrelevant research. However, the literature was scattered across a range of domains and subject areas, for example health, education, leisure and social behaviour. The challenge of designing the search strategy related to selecting the resources and testing how database searches could identify the research. It emerged that full-text searching was feasible and necessary for locating some research, as the name of the cohort study was not always mentioned in the titles and abstracts of relevant studies. Thirty databases were searched, including a specialist repository of working papers. The search identified 2,344 unique citations that were screened, resulting in finding 481 unique studies of interest to the review. This example demonstrates the range of connections between the four categories of dimension: research question and scope, terminology, information organisation and domain and

publication norms. In contrast, for the review on self-care for minor ailments (#7), database selection centred on healthcare databases. However, operationalising the multiple meanings and diverse terminology for the concepts of 'self care' and 'minor ailments' and capturing relevant citations from the databases proved challenging. Developing the database search strategy involved extensive iteration and the resulting database searches identified 16,081 records of which 58 records were used for the review synthesis.

4.6 Comparison of search strategy design for diverse literature with the candidate publications and the guidance and standards

The dimensions of search strategy design serve as way to describe the elements of search strategy design that are explored in my candidate publications.

4.6.1 Domain and publishing norms: multiple subject domains, diffuse dissemination and multiple search resource types

While domain-specific guidance exists on where to search, and there is an expectation that multiple sources are searched, the specific decisions on where to search are tailored to individual reviews. This can be informed by understanding the way information is produced in different contexts (Sundin 2008). However, such knowledge appears to emerge from experience, subject knowledge and knowledge of resources. This knowledge is not explicit, particularly for reviews in social policy that cover a range of research evidence. My publications highlight that such knowledge is important in several ways. Firstly, **CP2** provides evidence on the publication types in each resource and on database sources that yield each of 229 studies of people's views on public health topics. This publication also speculates on domain differences in publishing between social science and psychology. Secondly, the impact of source selection for one of these reviews highlights the problem of database selection bias (**CP1**). Thirdly, **CP5** reflects on the rationale for choosing which websites to search. It also suggests options for selecting websites sources include: consulting methods guidance, library resource lists, grey literature resource lists, reports of systematic reviews, topic advisers, Internet search engines or already known websites of interest. Fourthly, three of the candidate publications focus on resources used in four public health reviews (**CP1, CP2**) and three social care guidelines (**CP3**)

CP5 observes that identifying appropriate websites to search is highly dependent on the research question and knowledge and accessibility of the websites available. This differs from choosing bibliographic databases that cover specific disciplines or broad topic areas. A review team needs to

reflect on the purposes of website searching and how representative the websites are in relation to the focus of the review. For example, where reviews have a specific geographical focus, or span a variety of stakeholders, there needs to be an awareness of how representative websites are to those of that geographical region or stakeholder populations to avoid introducing 'source selection bias'.

CP5 suggests that categorising sources into relevant groups or themes could help during the planning stage. However, this does not detract from the challenge of identifying potential sources to search. Ideally such a planning approach would be broadened for use as a prompt to consider domain and publishing norms of a given systematic review topic, but this knowledge may not be known or accessible to systematic reviewers of cross-disciplinary topics. Case studies of the utility of databases are useful in informing and codifying this knowledge though may be limited in transferability to other topics. The findings are also influenced by how the sample of studies within the case study were collected and analysed, and the scope of the review they were identified for. My case studies (**CP1, CP2, CP3**) contribute to this knowledge.

4.6.2 Research questions and scope: multiple meanings of search concepts

The notion of "meanings of search concepts" is not described in the guidance and related standards literature. Within the section of research questions and scope, two of my candidate publications make observations on multiple meanings of search concepts. **CP3** reflects on challenges of multiple meanings of search concepts within three social care guidelines and describes steps taken to address these where it was possible. **CP4** reflects on how text-mining can inform development of search term selection. It is possible that through utilising specific tools, different meanings of search concepts may be revealed. However, this depends on having a suitable sample to analyse with text mining, and if the concepts within the sample are described by terminology to distinguish into the related sub-concepts. For example, text mining was found to be useful for identifying different meanings within the concept of 'older people and ageing' (e.g. future planning, longevity, menopause, active ageing), and the relative performance of three different tools in capturing these is shown in **CP4**.

In terms of the three other dimensions in the category of research questions and scope (search sample, establishing search concepts and searching strategy) my candidate publications draw on case studies that use comprehensive searching, establish search concepts *a priori* and use a linear searching strategy. Though **CP5** observes that decisions on which websites to search may be made *a priori*, these could change during the reviewing process if new resources are identified or where it emerges that some resources are not useful or are unwieldy to use.

4.6.3 Terminology: wide search term diversity

There are studies on search filter selection and the PRESS checklist within the guidance and standards literature. The studies on search filter selection inform on combinations of search terms for capturing specific search concepts such as the populations and study designs. The PRESS checklist can act as a prompt to audit the use and combinations of search terms.

The category of search term diversity is explored in two of my candidate publications. **CP3** provides examples of search term diversity within the social care literature in the process of designing search strategies for three guidelines. **CP4** describes how text mining can be used to gain a rapid overview of terminology used in a sample of citations or full-text articles. For diverse literature it posits this as an aid to informing search term diversity, rather than reliance on text mining alone. This is because the output from these tools is influenced by how the sample analysed has been initially collected and the nature of the text-mining tool utilised. **CP4** observes there appears to be an absence of useful tools for identifying synonyms and homonyms for the purposes of developing search strategies outside the medical literature, which rely on an external corpus (rather than using a corpus of studies sought by a searcher).

4.6.4 Information organisation (broad indexing and low discriminating power of search)

The specific decisions on which indexing terms to use in the search strategy are made for individual reviews. **CP3** describes challenges in using database indexing to search for three social care guidelines, and provides examples of indexing with a broader focus than the topic. **CP3** also shows inconsistencies of indexing within databases. It finds the Social Science Citation Index's automated indexing (keyword plus) to be beneficial in identifying a study missed from other database searches. While these issues with database indexing is well established, the case studies in **CP3** provide useful examples that could be applied to specific social care topics. The findings strengthen the case for searching multiple databases that have considerable content overlap, as this can mitigate the variations in indexing.

The search precision is the proportion of relevant studies from the results of the search. Sampson et al. (2011) estimate that typical search precision for healthcare reviews is 3%, and it ranges from 0.7% to 35% in their sample. Search precision in my case study of four public health reviews ranges from 0.2% to 1.97% (**CP2**) and for three social care guidelines search precision is under 0.6% (**CP3**).

CP4 examines the utility of different text-mining tools in supporting search term diversity. Of the five overarching ways in which text mining can be used to inform search strategies, three have particular application to diverse literature (increasing sensitivity, increasing precision, aiding translation across databases). **CP4** explores ways in which text mining can be used to increase search precision and increase sensitivity. It observes that text mining is not always useful owing to the nature of language and the studies of interest. **CP4** concludes that it is difficult to predict how useful text mining can be for diverse literature, owing to the nature of language in distinguishing potential studies of interest. However, **CP4** points out it can be used to complement other processes in developing search term strategies through using rapid, easily available tools. Clustering is particularly useful in identifying predominant irrelevant search terms, but only where these terms are not associated with terms used in relevant studies, and where there is a dominant vocabulary to express the irrelevant (or relevant) studies and where the clustering tool identifies a suitably informative label for the clusters containing these (**CP4**).

One of the challenges of website searching is how to search or navigate them appropriately. Potentially useful websites are likely to differ in their structure and content. **CP5** observes that more than one approach may be needed for searching each website and it is potentially unhelpful to treat searching each website in the same way. For example, separate searches with the terms 'hospital' or 'psychiatric' were specific enough to identify a small number of records on some websites but these may too generic on other sites. Some websites may be more appropriate for searching and others for browsing because of the way websites are organised. A combination of approaches could be complementary strategies (**CP5**). Based on my experience, I recommend that website providers should separate empirical research from opinion pieces and guidance tools to aid their identification (**CP5**).

Chapter 5 Influences on search strategy design

Influences on the decision-making of the dimensions of search strategy design are considered in this chapter. The influences were developed from my candidate publications and from analysing the ten reviews that were used to generate the dimensions of search strategy design. They were expanded on reflection of the guidance and related standards and the theoretical literature. Table 5.1 shows five themes on the influences of search strategy design from my candidate publications and the ten reviews: people, process, resources, evidence and technology. In section 5.3 I describe an expansion of these themes from considering the literature in Chapter 3. This adds two further themes: standards and creativity and the problem-solving processes within information searching.

Table 5.1 Thematic influences of search strategy design from my candidate publications and the ten reviews

Theme	Elements from my candidate publications are indicated	Elements from the ten reviews
People	<ul style="list-style-type: none"> Advisory group/ committee members (CP1) 	<ul style="list-style-type: none"> Topic experts on review team
Process	<ul style="list-style-type: none"> Scoping work or protocol iteration (CP3) Using a template to document website searching and browsing (CP5) 	<ul style="list-style-type: none"> Quality assurance Emergent during the review process Searching/screening and protocol iteration Test searches Topic familiarisation
Resources	<ul style="list-style-type: none"> Browsing websites to decide which to search (CP5) 	<ul style="list-style-type: none"> External register of likely relevant records for testing search Similar systematic reviews Time/ rapid review constraints Availability of resources Browsing library catalogues for sources
Resources/ Evidence	<ul style="list-style-type: none"> Selecting a resource based on findings of Stansfield et al. 2012 and 2014 (CP1, CP2) 	<ul style="list-style-type: none"> Other search filters or terms from systematic reviews
Technology	<ul style="list-style-type: none"> Text mining to increase precision and reduce sensitivity (CP4) Search interfaces – require two-word searches and browsing (CP5) 	<ul style="list-style-type: none"> Specific database fields (e.g. diagnostic tests in PsycINFO)

5.1 Describing the influences of search strategy design in my candidate publications

People

Significant human input is necessary for search strategy design, including choosing search terms, running test searches and browsing results. **CP1** evaluates impact of the advisory group on review findings, through suggesting databases to be searched that were not in the original review protocol. I am not aware of another publication that has shown this. Bayliss and Dretzke (2006) describe the database sources that an advisory group suggested that were additional to their protocol and their reasons for inclusion or exclusion, but do not evaluate the specific intervention.

The case study analysed in **CP4** demonstrates that manual reflection is necessary for applying and developing a search strategy. It found that although text mining could inform on suitable search terms, and clustering to inform on the precision of a search, human input was needed to develop a conceptual modification to the search.

CP5 recommends that the person undertaking website searches has sufficient understanding of the type of information that is being sought from the literature search, as well as skills in locating and managing literature found from websites. This is particularly important owing to pragmatic decisions that need to be made when searching individual websites: Searching and browsing websites typically involves an element of screening to select relevant studies at source, rather than an approach centred on searching and selecting all for screening at a later time-point (**CP5**).

People, processes and technology

The interlinks between people, processes and technology can also influence search strategy design. The distinction between the boundaries of these three themes is unclear. Four elements not described elsewhere in this section are highlighted from two publications, **CP4** and **CP5**.

CP4 observes that processes of text mining for search term development may interact with the screening processes; there is no need for using text mining to improve search precision, if relatively higher volumes studies can be screened through automation than with manual screening. A disadvantage of this is that the quantity of studies that need to be screened manually is not known until after the searching has taken place. Secondly, **CP4** observes that judging how best to utilise text-mining tools for specific purposes is an important consideration in using the tools. Thirdly, my experience has been that the process of recording how a websites is searched, helps in considering

the search approach (**CP5**). For example, recording which navigation headings are browsed and which search terms are used helps a searcher reflect on their rationale of choosing these and may prompt useful iterations of searches. In doing so, recordkeeping encourages a degree of care, enables comparison of approaches across different websites, and aids a consistent approach across similar resources. Finally, **CP5** suggests that having considered rationale for searching websites helps the process of searching websites to be accountable, though it recognises that such a rationale is influenced by the knowledge and skills of the searcher, and the time and resource constraints under which a review takes place.

Process

CP5 develops a process template for conducting website searching and discusses conceptual approach of process of website searching. It observes that there is little guidance on conducting website searches for systematic reviews. Secondly, using text-mining tools as an aid to search term development introduces more steps and time into existing processes of search strategy design. Furthermore, decisions need to be made on operational issues in utilising the tools, which include, deciding on the threshold under which a list of terms in ranked order are not checked.

Resources

CP1 shows that geographical bias is important to consider when researching geographical areas, and **CP5** discusses rationale in selecting sources of website searching. My case studies on search sources in public health qualitative research (**CP1**, **CP2**) and social care (**CP3**) offer unique findings on resources in the specific topic areas in which they focus on. Additionally, **CP2** generates evidence for publication norms in certain resource types in public health qualitative research.

Evidence

All the examples listed in 'resources' could also be considered as 'evidence'. Additionally, **CP4** provides some evidence on utility of certain text-mining tools.

Technology

CP4 develops a typology of applications of text-mining tools for search term development. It is also a case study and discussion on benefits and limitations and utility of different approaches and techniques. Text-mining technologies have the potential to reveal patterns on the search terms or the type of literature that the search is locating; for example, rapid clustering of citations, ranking of predominant search terms based on statistical and linguistic 'importance', ranking of word frequencies and co-occurrence. In doing so they help humans rapidly appraise large volumes of citations that would be vastly time-consuming or impossible to undertake otherwise. **CP4** discusses the utility of text-mining tools. Some utility relates to the varying functionality of the tools themselves, for example, where some are developed only for specific datasets, clustering tools being able to describe a suitable label, and point of speech parsers identifying pertinent phrases. However, the way they are used and the text that is analysed also influences utility. All the tools described in **CP4** were generic and none were designed with search strategy development in mind, therefore a two-step process was needed for many tools in order inform how many citations relate to a corresponding search term. Finally, there is potential for technology to influence other aspects of search strategy design. **CP5** observes a potential for technology in recordkeeping websites and how this may influence search. **CP1** observes the influence a potential technology bubble in possibly perpetuating geographical database selection bias.

5.2 Themes on influences of search strategy design from the sample of ten reviews

Table 5.1 shows the themes and elements as elucidated from the ten reviews described in Chapter 4. This adds breadth of additional elements to those explored within my candidate publications. It also indicates there are a multitude of influences in search strategy design, and that therefore this is not comprehensive. However, they sit within the same five themes as those from my candidate publications. Furthermore, influences of search strategy design may not be documented. Six of the 20 elements are not described within the reviews: Two were added from other analyses. The influence 'on using a template to document website searching and browsing' is described in my candidate publication (**CP5**), and in Brunton et al. (2017, p115 (**SP1**)). The influence of 'specific database fields (e.g. diagnostic tests in PsycINFO)' emerged as a result of an unpublished retrospective analysis of sources for one review. The four other elements that I recalled following reflection of how I designed the search strategies for the specific reviews were: topic familiarisation,

availability of resources, browsing library catalogues for sources, and browsing websites to decide which to search.

5.3 Expanding the themes of influence of search strategy design

Two other themes emerge from considering influences on search strategy design from the guidance and related standards (listed in Table 3.1), and the theoretical literature. Firstly, standards, which include guidance, expectations and norms of systematic searching and differences between research environments. Secondly, creativity and the problem-solving processes within information searching. I consider this latter theme as separate from 'people', as it relates to people's interaction with technology. Although Chapter 3 describes the information sought as an influence on search strategy design, I consider this to fall within the dimensions under 'research questions and scope'.

The observation that different influences emerged between the reviews, and that some influences are not identifiable from within the review, indicates that there may be other influences not considered here. These influences of searching were presented to a group of ten information specialists within the NICE Joint Information Group, in July 2017, with favourable feedback. Two new themes included: a need for reproducibility, and how potential risk of missing studies is managed (such as other steps in the process to identify evidence (committees, consultations))¹. In consideration of these suggestions I consider these elements to fall within the existing categories of standards and process.

¹ Email correspondence from J Boynton, 11 July 2017, citing a summary for inclusion in the meeting minutes.

Chapter 6 Conclusion

6.1 Addressing the research questions

RQ1: What is the current state of knowledge in relation to designing search strategies for systematic reviews of diverse literature (particularly within public health and social care)?

The review in Chapter 3 shows that there are a variety of guidance documents, commentaries, reviews and individual research studies that inform methods for search strategy development. The current practice of designing search strategies that relate to systematic reviews in public health and social care is underpinned by generic guidance on searching processes, some empirical literature and practice from experience. The guidance sets out standards and principles of searching. The guidance permits all approaches as long as the approach is justifiable for accountability, and documented for transparency and potential reproducibility.

Methods and expectations of database searching have developed from practices used in clinical effectiveness research, which appear to be based upon professional experience and supported by some evidence. Recent reviews show gaps in the evidence base for qualitative research and quasi-experimental study designs (Glanville et al. 2017, Booth 2016). Though clinical health intervention reviews are challenging to undertake, the challenges of searching for diverse literature seem magnified rather than distinctly different, such as where to search, defining the search, subjective bias of approach, and a dissonance between user need and how information is organised. Information retrieval systems and users' approaches to utilising these vary. Although guidance sets out the specific elements to consider when designing search strategies, a number of arbitrary decisions must be made on a case by case basis, such as choice of one source over another and how best to determine which search concepts to focus on. Researchers are exploring alternative methods and approaches for searching systematically, though there is a need to strengthen the evidence base to inform practice. The theoretical literature demonstrates the range of factors which interact when conducting searches.

The concept of 'diverse literature' is not defined in the literature. In considering systematic literature searching for diverse literature, there appears to be a lack of consideration of the following: the reasons that searching is complex; a linkage of theory to practice; and a critique of the standardised approaches used. There also appears to be a paucity of research connecting models and theories of information seeking with systematic reviews.

Designing search strategies involves judgements on how best to capture literature within the time and resources available. There is a tension between being efficient and sensitive in searching, but not missing important studies or concepts across all reviews. There will always be limitations in locating and accessing research, particularly where the research is fragmented or organised in ways that do not meet individual needs of the research. Searching aims to locate either a comprehensive sample or a selective sample; the search concepts may be *a priori* or emergent, and the search strategy (relating to the resources and search terms) may be linear or iterative. My review of this literature is unique in describing and configuring the challenges and influences of designing search strategies as related to diverse literature.

RQ2: How do the findings of the candidate's case studies and the methods used for designing search strategies, as demonstrated in her other publications, collectively inform practice?

All of my publications analyse and explore searching methods for diverse literature to inform practice and methods development, particularly within the realm of social policy-relevant systematic reviews in public health and social care. In doing so, they individually make significant contributions to knowledge. Collective examination of these publications shows how they contribute to understanding search strategy design, in terms of publication and dissemination norms, diversity in terminology and in the discriminating power of search terms, and in influencing decision-making on these dimensions.

Collectively examination of my candidate publications prompted me to explore the nature of diverse literature and the implications of this for search strategy design. I observed a gap in the literature in defining diverse literature in the context of designing search strategies for systematic reviews. Four categories comprising ten dimensions of search strategy design emerged from analysing search strategies developed for ten systematic reviews. Seven of these ten dimensions contain characteristics that describe aspects specific to diverse literature: multiple subject domains, diffuse dissemination, multiple search resource types, multiple meanings of search concepts, wide search term diversity, broad indexing terms, and low discriminating power of search. While the remaining three dimensions are integral dimensions to search strategy design in general, the differences within these dimensions do not necessarily characterise diverse literature: search sample, establishing search concepts, searching strategy.

The ten dimensions seem useful for informing practice as they show the separate elements that need to be considered when designing a search strategy. Decision-making on these dimensions is influenced by different factors. Overarching themes from this analysis are: people, processes, resources, evidence and technology.

My candidate publications add depth to the influences of search strategy design, which would not have been known otherwise. Exploring search strategies in this way facilitates understanding of the considerations and challenges in designing and planning a systematic literature search.

RQ3: How do the findings from RQ1 and RQ2 contribute to understanding the design of search strategies for diverse literature?

The dimensions of search strategy design enable articulation of the multiple aspects that need to be considered. My publications only represent a partial view of search strategy design, and this has been integrated into related research and guidance. A holistic model of searching is shown in Figure 6.1 that is configured from my thinking about how the dimensions of search strategy design fit within a range of perspectives on searching for diverse literature. This has enabled the generation of higher order themes on search strategy design that are potentially generalisable.

The higher-level themes of influences of search strategy design emerged from exploring four types of literature: guidance and related standards, literature linking theory and systematic reviews, my candidate publications and the sample of ten systematic reviews. These four literatures each reveal different themes. The two categories of standards and creativity or problem-solving processes within information searching were added to the five other themes which emerged from analysing my candidate publications and ten reviews: (people, processes, resources, evidence and technology).

The model of search strategy design illustrates how the dimensions and categories relate to each other in the systematic process. An increased understanding of designing search strategies for systematic reviews improves transparency of the process, which is useful in encouraging reflective practice on search strategy design for systematic reviews and in considering the meaning and processes of being systematic in practice. The model also informs and questions criteria on how search strategies for systematic reviews are evaluated and on utilising advances in technology that affect how literature is organised, identified and displayed.

Figure 6.1 Model of search strategy design and key contributions of my candidate publications (same as Figure 2.1)

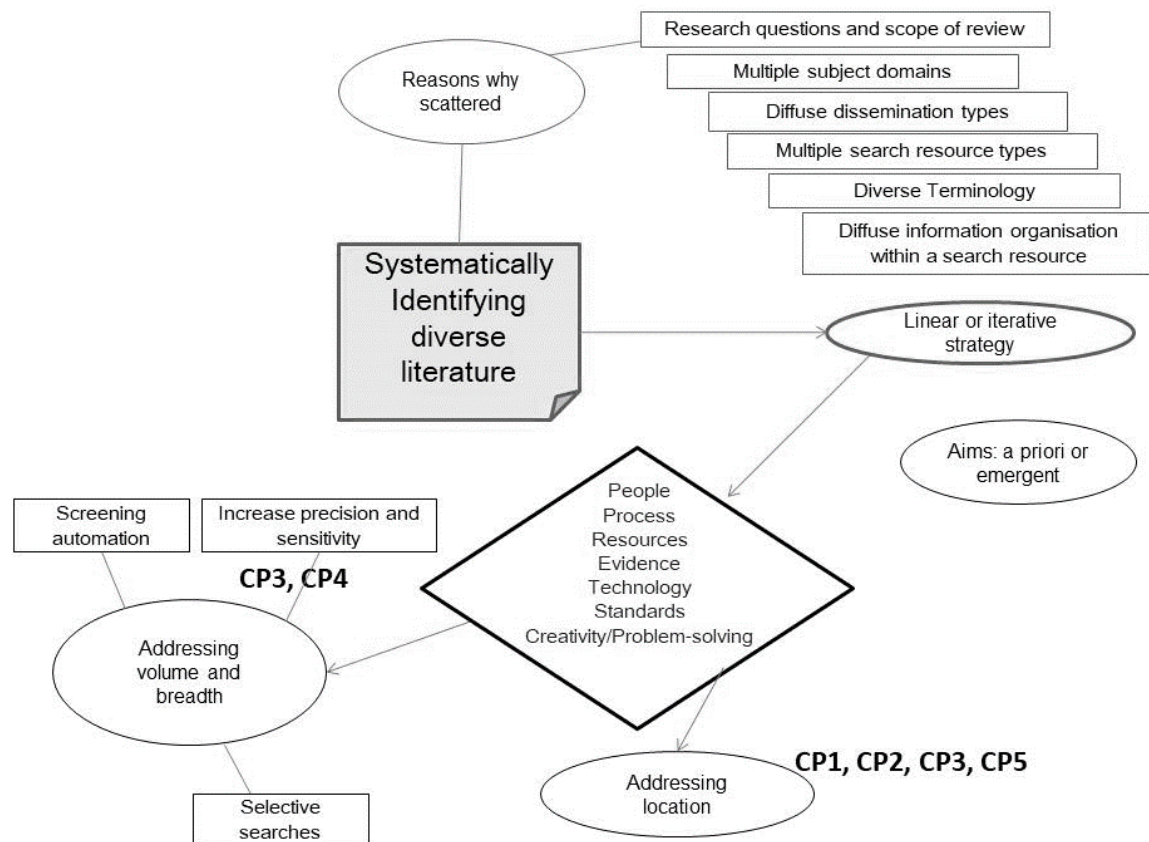


Figure 6.2 Thematic categories and ten dimensions of search strategy design (same as Figure 4.1)

Thematic category	Dimension	Range
Domain and publishing norms	Subject domains	Multiple ↔ Single
	Dissemination	Diffuse ↔ Narrow
	Search resource types	Multiple ↔ Single
Research questions and scope	Search sample	Comprehensive ↔ Selective
	Establishing search concepts	Emergent ↔ <i>A priori</i>
	Meanings of search concepts	Multiple ↔ Single
	Searching strategy	Iterative ↔ Linear
Terminology	Search term diversity	Wide ↔ Precise
Information organisation	Indexing	Broad ↔ Specific
	Discriminating power of search	Low ↔ High

6.2 What are the implications for further research?

This thesis highlights the importance of sharing evidence for methods development, and the different perspectives gained from drawing on a range of literatures. The model of search strategy design could be strengthened by comparing it with an analysis of the review reports of diverse literature undertaken in other research environments to the EPPI-Centre, and interviewing those involved in designing the search strategies to understand how they make decisions. This thesis has taken a broad perspective of search strategy design, and there are a variety of areas for further research. For example, the connections between information theory and literature searching to identify studies for systematic reviews could be explored in order to further understand and develop methods. In addition, the role of problem solving and creativity in systematic searching methods is not developed in the literature, though seems to be integral to developing effective literature searches. This may be particularly timely to explore given an increased focus in using automation for undertaking systematic reviews. Furthermore, the increased role of automation may provide opportunities in iterative search strategy design, where the search strategy is evaluated and developed by studies that have been assessed and included in a systematic review. Another area of research would be to examine how there could be a clearer linkage between communication and publication norms of research studies and systematic review searching methods. This is particularly important given the changing nature of scholarly communication and predicted increase in systematic reviews utilising publishing datasets as well as research reports of studies.

6.3 What are the implications for practice?

The model of search strategy design for systematic reviews encourages reflective practice on the meaning of being systematic and implementing appropriate processes. The holistic perspective facilitates understanding the opportunities and limitations for identifying diverse literature and aids in developing practical and considered rationales for designing search strategies. It also provides context for the critique and development of searching methods, and helps in both communicating issues and managing expectations on literature searching, within a review team and with other stakeholders.

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Appendix 1 Candidate publications

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CORRESPONDENCE

Open Access

The selection of search sources influences the findings of a systematic review of people's views: a case study in public health

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Abstract

Background: For systematic reviews providing evidence for policy decisions in specific geographical regions, there is a need to minimise regional bias when seeking out relevant research studies. Studies on people's views tend to be dispersed across a range of bibliographic databases and other search sources. It is recognised that a comprehensive literature search can provide unique evidence not found from a focused search; however, the geographical focus of databases as a potential source of bias on the findings of a research review is less clear. This case study describes search source selection for research about people's views and how supplementary searches designed to redress geographical bias influenced the findings of a systematic review. Our research questions are: a) what was the impact of search methods employed to redress potential database selection bias on the overall findings of the review? and b) how did each search source contribute to the identification of all the research studies included in the review?

Methods: The contribution of 25 search sources in locating 28 studies included within a systematic review on UK children's views of body size, shape and weight was analysed retrospectively. The impact of utilising seven search sources chosen to identify UK-based literature on the review's findings was assessed.

Results: Over a sixth (5 out of 28) of the studies were located only through supplementary searches of three sources. These five studies were of a disproportionately high quality compared with the other studies in the review. The retrieval of these studies added direction, detail and strength to the overall findings of the review. All studies in the review were located within 21 search sources. Precision for 21 sources ranged from 0.21% to 1.64%.

Conclusions: For reducing geographical bias and increasing the coverage and context-specificity of systematic reviews of people's perspectives and experiences, searching that is sensitive and aimed at reducing geographical bias in database sources is recommended.

Background

Theory on comprehensive searching for research about people's views in public health

Systematic reviews of people's views, understandings, beliefs and experiences ('views studies') are valuable to policy-makers in providing contextual information on interventions to inform their development, implementation and evaluation [1]. We describe 'views studies' as those that are centred on people's own voices; these are

often qualitative, but not always [1]. Undertaking a systematic literature search for these studies contributes to the rigour and quality of the review findings, but the process of identifying research on people's views can be challenging. Studies on people's views tend to be dispersed across a range of subject disciplines, are diverse in their terminology, and exist in various publication formats. People's views of public health issues potentially cross over the fields of social science, the environment, health and medicine, education and psychology. They are contained across a range of literature search sources from large ubiquitous databases to smaller specialised datasets focused on specific subject areas. Furthermore, there is large variation in the terminology used to

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describe research methods and in the database indexing of relevant literature [2-4]. Although many studies are published as journal papers, a significant proportion are disseminated in research reports, books, theses and conference proceedings [5].

As many systematic reviews are commissioned to provide evidence for policy decisions in specific geographical regions, there is a particular need to minimise regional bias when seeking out research studies. Gomersall and Cooper [6] highlight the potential bias through selecting large US-based medical databases to seek out information for UK-policy relevant reviews in social science. Although there is no guarantee that searching a wider range of databases increases the percentage of relevant papers identified, failing to consider the breadth and geographical representativeness of the databases selected raises concerns about evidence that could have been missed. We describe this concept as 'database selection bias'.

We are not aware of research published on database selection bias that relates to the selection of search sources and its effect on the findings of a systematic review. Song et al. [7] classify a range of biases associated with publishing and identifying research in reviews of health care effectiveness and related areas. They refer to geographical bias in the context of database-indexing and observe that some databases contain a predominance of journals from specific geographical regions [7], p35. Howes et al. [8] reflect on biases relating to searches within the public health literature. Other authors have assessed search sources utilised for systematic reviews within the broad field of public health and social care [9-11], and there are other case studies of search sources used in systematic reviews of qualitative studies in public health [12] and education [13]. However, none of these examine the impact of database selection bias on the findings of a review of people's views.

There is no clear consensus on the methods used to locate views studies for systematic reviews. In seeking views studies in public health, researchers at the Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre) search across a range of sources using many free-text and controlled vocabulary search terms. The approach attempts to find all relevant research studies. However, this idealistic concept is limited by practical constraints, such as access to resources, time invested in developing the search strategy and searching for studies, and knowledge of both appropriate search sources and search terms.

Applying theory to practice – literature searching undertaken for a systematic review of people's views

We now present results from a retrospective analysis of search sources used for a review of children's views about

obesity, body size, shape and weight [14]. The review was undertaken to help inform policy development at the UK Department of Health in relation to children and obesity. It drew on both qualitative studies and other study designs, and sought studies based in the UK in order to maximise its relevance to UK policymaking.

The literature search for the review involved: carrying out extensive and sensitive searches of nine bibliographic databases (using controlled vocabulary and many free-text terms) from a range of disciplines; hand-searching of three journals, 16 websites and reference lists; contacting authors and other key informants; and forward citation checking (looking for studies that cite studies included in the review). The database searches were based upon one or more of the following three concepts: body size; children; and people's views or qualitative study designs. These were limited to English language studies published from 1997 until the date of searching, which was during June and July 2008. A draft search strategy was detailed in a review protocol, which was circulated to the advisory group of the review and made publicly available on the EPPI-Centre's website. Feedback from AG in the advisory group prompted supplementary searches of seven additional sources that could potentially contain more UK-based studies. The search sources are presented in the Results section. The full search strategy is detailed within the published review [14], on pages 131–139.

Search results were uploaded into a review management software tool (EPPI-Reviewer 3.0) [15] and duplicate papers of the same record were removed. The remaining reports were screened on the basis of their title and abstract, and relevant items were then screened on the full-text of the paper/report. Twenty-eight studies were entered into the review's syntheses. Study quality was appraised using criteria adapted from Shepherd et al. [16], and is explained in the published review. This focused on two areas: i) the reliability of study findings (based on the rigour of study methods including sampling, data collection and data analysis; and whether findings appeared grounded in or supported by data); and ii) the usefulness of study findings (based upon the breadth and depth of findings as well as whether there was evidence of attention by researchers to an ideal of privileging young people's views [1,14]).

Two separate syntheses were conducted: one interpretive, which developed overarching themes from the study findings [17]; and one aggregative, which identified similarities and differences between studies addressing similar research questions. Thematic codes were applied to each of the studies included in the interpretive synthesis. An Excel spreadsheet was used to capture the questions addressed by studies in the aggregative synthesis.

Aims and research questions

The aim of this case study is to examine the impact of database selection bias on the findings of a review of UK children's views of body size, shape and weight. Our research questions are: a) what was the impact of search methods employed to redress potential database selection bias on the overall findings of the review? and b) how did each search source contribute to the identification of all the research studies included in the review?

Methods

The impact of using additional search sources to minimise database selection bias was assessed by determining how many new studies were located, and how the studies influenced the findings of the systematic review. Search source data for the studies included in the review were obtained from EPPI-Reviewer 3.0 [15], which contains a record of where each study was found. Where multiple papers had been published about the same study, the paper (and, by association, its source) identified first was selected to represent the study. The impact of the five additional included studies [18-22] on the review findings was assessed by retrieving the qualitative themes (and codes) applied to each study, along with the related extract of the study text. The contribution of each of these studies to the synthesis was assessed by counting how many distinct themes had been attached to that study and comparing this with the themes assigned to the other studies [23]. A note was also made of the quality rating given to each study. To explore the contribution of the types of search sources used to locate studies, the sources were grouped into those that were in the original protocol; and those that were introduced into the search strategy after the first draft of the protocol had been reviewed. Where possible, the relevance of the retrieved records from each search source, expressed as precision, was determined as the proportion of studies included, compared with the total identified from the search query.

Results

This section details our findings according to our two research questions: the first examines the impact of the additional search sources on the findings of the systematic review; the second section describes all the search sources and how each contributed to the number of studies judged to be relevant for answering the review question.

Research question 1: What was the impact of search methods employed to redress potential database selection bias on the overall findings of the review?

Table 1 summarises the distribution of included studies among sources split from the original search protocol and supplementary sources searched later to address geographical bias. While most of the studies were found

from the original protocol, over a third of studies were also identified in the later sources and nearly a fifth were only found within these sources. Three of the seven sources used in the supplementary searches provided five studies that were not found by other means. Table 2 shows these five studies, their quality ratings and their contribution to the themes within the review. In terms of quality, three of the five studies were judged to have findings that were highly reliable. In the review as a whole, only two further studies were awarded this quality rating. All of the five studies contributed to the review's syntheses: one contributed to the interpretive synthesis (of the overarching themes in children's discussions of body size); and four contributed to the aggregative synthesis (of similarities and differences between studies).

The single study by Stewart et al. [19] that contributed to the interpretive synthesis contributed to three of the 17 themes identified in this synthesis. It is possible that without this study, one theme ('size matters later') would have been relegated to a passing mention within a higher order theme, or might not have been considered at all. Only in Stewart et al. [19] was the idea of adult and children's experiences of food and size interpreted as an important theme by the authors. In each of the other two studies coded with this theme, the reviewers had mentioned age and body size within an individual quote, but the studies' authors had not made this connection. The other two themes in Stewart et al. [19] ('diet and exercise as influences' and 'appropriate strategies') were developed using findings from four and eight other studies, respectively.

The four additional studies that were placed in the aggregative synthesis contributed, in total, to six of this synthesis' seven themes. All of these themes were, however, usually supported by findings from at least five other studies that had been found with the original searches. While the findings may have looked relatively similar if these studies had not been found, the retrieval of these four additional studies added breadth, depth and strength to this synthesis, thus increasing the quality and rigour of the findings

Research question 2: How did each search source contribute to the identification of all the research studies included in the review?

Table 3 shows the utility of the 25 search sources in finding studies for the systematic review. Studies judged potentially relevant on title and abstract were found in all search sources (data not shown). The 28 studies ultimately included in the review were located in 21 search sources (this includes duplicate papers found in more than one location). The largest sources of studies were among three international medical and social science databases: Pubmed = 8 (15%); PsycINFO = 7 (13%); and the Social Sciences Citation Index (SSCI) = 7 (13%). While these

Table 1 Distribution of included studies across search source groups

Search source type and stage of searching in protocol	Search sources	Included on full-text (N = 28)*	Studies only found within this group of sources (% of 28 studies)
Bibliographic database search sources in original search protocol	Applied Social Sciences Index and Abstracts (ASSIA); Bibliomap; Cumulative Index to Nursing and Allied Health Literature (CINAHL); Education Resources Information Center (ERIC); HealthPromis; PsycINFO; PubMed; Social Sciences Citation Index(SSCI); Dissertation Abstracts;	16 (57%)	9 (32%)
Search engines in original search protocol	Google and Scirus	3 (11%)	1 (3.5%)
Non-database sources in original protocol	Author contact; forward citation checking (Web of Knowledge); reference list checking; previous EPPI-Centre review; 16 websites; handsearches of 3 journals	8 (29%)	6 (21%)
Supplementary search sources	British Education Index; Child data; IBSS; Index of British Theses; Social Care Online; (The British Library Integrated Catalogue and Zetoc were also searched but did not yield additional studies)	10 (36%)	5 (18%)

*total exceeds 28 as some included studies were identified in multiple categories.

figures include duplicate records of the same study, over a third of the studies in the review were identified from these three sources (11/28 = 39%). Other databases each

identified three or fewer studies. Six studies were found only using non-database sources (author contact, website handsearching, a previous EPPI-Centre review and

Table 2 Assessing the Impact of additional five studies on the findings in the review

Study	Search source	Reliability of findings	Usefulness of findings	Contribution to themes within the review synthesis(No. of other studies contributing to the theme)
Aggregative synthesis				
Currie et al. [20]	Child data	High	Low	1 theme: Satisfaction (12)
Currie et al.[18]	Child data	High	Low	1 theme: Satisfaction (12)
Harris [21]	Index of British Theses	Medium	Low	5 themes: Estimations (8) Preferred size (9) Satisfaction (12) Stereotyping (6) Importance/concern (2)
Waterston [22]	Index of British Theses	Medium	Low	4 themes: Estimations (8) Preferred size (9) Satisfaction (12) Other – relation between self-esteem and experience of size-related bullying (1)
Interpretive synthesis				
Stewart et al. [19]	IBSS	High	Medium	3 themes: Size matters later (3) Diet and exercise as influences (9) Appropriate strategies (5)

Table 3 Utility of search sources in identifying relevant studies

Search source	Records retrieved from search	Studies included from that source (% precision)	Studies included that were unique to that source
Applied Social Sciences Index and Abstracts (ASSIA)	625	3 (0.48%)	1
Author contact (n ≥ 50)	n/a (12)	2	2
Bibliomap (EPPI-Centre health promotion research register)	16	1 (6.25%)	
British Education Index	61	1 (1.64%)	
British Library Integrated Catalogue	n/a (9)		
Child data	561	2 (0.36%)	2
Cumulative Index to Nursing and Allied Health Literature (CINAHL)	1703	2 (0.11%)	
Dissertation Abstracts	451	1 (0.22%)	1
Education Resources Information Center (ERIC)	468	1 (0.21%)	1
Forward citation checking (Web of Knowledge)	88	1 (1.14%)	
Google	100*	2	
Google Scholar	300*		
HealthPromis (UK Health Development Agency research register)	235	2 (0.85%)	
Index of British Theses	n/a (16)	2	2
International Bibliography of the Social Sciences (IBSS)	402	5 (1.24%)	1
Journal hand searching (3 journals)	n/a (13)		
Previous EPPI-Centre review [24]	n/a (13)	2	2
PsycINFO	1691	7 (0.41%)	
Pubmed	3697	8 (0.22%)	2
Reference checking of included studies	n/a (20)	1	1
Scirus (scientific research search engine)	200*	1	1
Social Care Online	150	1 (0.67%)	
Social Sciences Citation Index (SSCI)	1915	7 (0.37%)	
Website hand searches of 16 sites	n/a (8)	2	1
Zetoc (British Library's electronic table of contents)	n/a (12)		
TOTAL	12766	54 studies**	17studies**

n/a = screening was offline and a complete record of total items retrieved and screened is not available.

*The quantity screened from a larger list of search results, therefore precision is not calculated.

**54 studies from 61 research records, which following removal of duplicates were 28 studies of which 17 studies were unique to one source.

reference checking). One study was found only from the search engine Scirus. Seventeen of the 28 studies were located in one place (unique studies) and these were spread across 12 search sources, with no single source identifying more than two unique studies. Precision ranged from 0.21% for ERIC to 1.64% for the British Education Index. In terms of overall performance, the Pubmed search yielded the most records to screen (3697) and had a precision of 1.57%, but provided the highest number of

studies included within the review, including two unique studies.

Discussion

The five studies identified through the additional searches had an important impact on the review findings; indeed, one study had a central role in the development of one of the review's descriptive themes. The other four studies were less influential, but added detail and

strength to the review's findings. If this group of additional studies had not been found, the syntheses would have been a less complete story of children's views of body size. These five studies were also of a disproportionately high quality compared with the studies in the review as a whole and so added to the robustness of the reviews findings. This runs counter to previous findings on sourcing health effectiveness studies where additional searches designed to increase a review's comprehensiveness have been limited in use because of the low quality of the research found [25].

We have shown that a small number of studies located from searching databases in addition to those specified in the original review protocol had a significant impact on the outcome of the final review. Although this case study is based upon 28 studies included in one review, the studies were from different subject disciplines, dispersed across a range of databases, and over a fifth were located from sources other than databases or search engines. In this case, a small number of studies were found in several places across large international bibliographic databases, and for other studies, the research records were scattered across a range of search sources over the disciplines of medicine, social science and education. At the outset of the systematic review it was anticipated that the literature would be widely dispersed. The original search protocol aimed to draw on a large sample of studies from a range of sources. It contained sources judged to potentially contain good sources of UK studies, notably: Applied Social Sciences Index and Abstracts (ASSIA), Bibliomap (EPPI-Centre's register of health promotion research), and HealthPromis (a UK Health Development Agency database that is no longer updated). ASSIA is an international social science database comprising of largely of journals published in the UK (46%) and in the USA (43%)[26]. The later searches of seven additional sources provided a greater UK focus to the search strategy. These contained UK studies not found by other means, rather than containing exclusively UK studies. For example, the International Bibliography of Social Sciences (IBSS) covers a large range of countries, and a majority (18%) of its source titles are published in the UK [27]. We cannot provide an accurate assessment of the time taken to undertake the additional searches. It involved a visit to another library to access one database; for some databases multiple simplified searches were undertaken owing to limited search functionality; and some databases were scanned at source, owing to restrictions in downloading the research records.

Although this case study is based on the results of searches used in the review, rather than what is actually present within the search source, we consider this justified as it is representative of the process of searching for a systematic review. The search strategies used for each

database source were conceptually the same with variations depending on the functionality and volume of records. The database searches were intended to be sensitive, using a range of free text and controlled vocabulary terms, and this is demonstrated in Table 3 by the low precision values. Publication type has only been given a cursory consideration here, and when searching for specific types of research, the nature of the publication type may also have an impact in deciding where to search.

Searching for 'views' studies can involve considerable investment of resources. The low precision found from database sources is consistent with published findings, such as Shaw et al. [2] who report a precision of under four percent in database searching for qualitative studies. For such a small number of studies, it would not be sensible to use this case study for selecting one search source over another, but it is useful in increasing awareness of the types and range of sources that might be useful in limiting database selection bias. Search engines such as Google and Scirus are difficult to search comprehensively, but they can be used for supplementary searching to locate potentially useful studies. Response from contacting authors can be a good source, although this method has unpredictable outcomes. Forward citation chasing was not effective in yielding any new studies in this case; however, it was limited to Web of Science Cited Reference Search and in retrospect, additionally utilising a citation search database that covers non-journal reports and dissertations may have improved this. Our finding that a high proportion of studies (21% (n = 6)) were obtained only from non-database sources (as shown in Table 1) is similar to other studies of searching for qualitative research [12,13].

Identifying search sources for systematic reviews can be challenging, but could be improved with more knowledge-sharing between information specialists and researchers. There will always be limitations on how wide one is able to search, the number of strategies that can be employed to improve comprehensiveness and reduce database selection bias, and relevant studies could be missed. Making more informed choices of where to search can mitigate the effects of this. The EPPI-Centre is building on this case study and comparing search sources across a number of systematic views of people's views [5].

Locating studies from a particular region is not just relevant to 'views' studies. A greater awareness of the value of searching a wider range of sources and the geographical slant of sources has contributed to the search protocol for other public health reviews within the EPPI-Centre. In undertaking other reviews we have identified other small databases and websites that could be of potential use. It can be challenging for the user to discover what is covered by a database or how publication sources are selected for inclusion, particularly where journals are partially indexed. In this case study, two included studies

were from the Health Education Journal, and both were not picked up by database searches. Further investigation revealed partial indexing of this journal in electronic database sources and has provided a case for hand-searching of this journal in later reviews.

The impact of new technologies on the choice of database is another consideration. Some databases have had substantial investment in their IT infrastructure. PubMed, in particular has spawned a small ecosystem of supporting services which all build on and publish the PubMed dataset in different forms. GoPubMed offers semantic and other analyses of PubMed documents in an interface that few social science databases can match. HubMed offers an alternative interface and a highly useful 'citation finder' which enables users to copy and paste bibliographies into a text box that processes this into a list of citations with links to their PubMed records. PubMed itself offers an open application programming interface (API) that enables programmers to integrate searching PubMed into their applications. These new services are innovative and demonstrate the potential of modern IT technologies. However, they are becoming a source of potential bias, as the very availability and accessibility of these services promotes the PubMed dataset above smaller, regional databases.

Conclusions

Our findings highlight the value in careful consideration of search sources in developing a search strategy, although searching more extensively does not guarantee locating more quality studies. Selecting sources on the basis of topic-coverage and study design is well-established, and we urge consideration of the geographical nature of database sources where appropriate. Policymakers, researchers and practitioners should be aware of the potential impact of where research literature is drawn from on the findings and relevancy of systematic reviews. This retrospective analysis demonstrates that 'database selection bias' can influence the outcome of a systematic review. It illustrates how the choice of search sources can increase geographical relevance. Despite aiming for comprehensiveness in literature searching, there are limitations in what can be found. A search protocol covering a range search sources, appropriate subject disciplines and geographical regions reduces the potential for missing important studies. This study has also demonstrated the value to be gained from obtaining external input into the review protocol from an advisory group. Owing to the lack of published research and case studies on both database selection bias and searching for views studies, there is a need for further dissemination and knowledge-sharing by information professionals and systematic reviewers on search sources for reviews.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

CS, JK, AG and RR generated the concept and design of the study. CS analysed the search sources and RR analysed the impact of the studies on the systematic review. All authors participated in the development of the manuscript from its early stages. All authors contributed to and approved the final manuscript.

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Original Article

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Search wide, dig deep: literature searching for qualitative research. An analysis of the publication formats and information sources used for four systematic reviews in public health

Claire Stansfield,* Ginny Brunton and Rebecca Rees

Background: When literature searching for systematic reviews, it is good practice to search widely across different information sources. Little is known about the contributions of different publication formats (e.g. journal article and book chapter) and sources, especially for studies of people's views.

Method: Studies from four reviews spanning three public health areas (active transport, motherhood and obesity) were analysed in terms of publication formats and the information sources they were identified from. They comprised of 229 studies exploring people's perceptions, beliefs and experiences ('views studies') and were largely qualitative.

Results: Although most (61%) research studies were published within journals, nearly a third (29%) were published as research reports and 5% were published in books. The remainder consisted of theses, conference papers and raw datasets. Two-thirds of studies (66%) were located in a total of 19 bibliographic databases, and 15 databases provided studies that were not identified elsewhere. PubMed was a good source for all reviews. Supplementary information sources were important for identifying studies in all publication formats.

Conclusions: Undertaking sensitive searches across a range of information sources is essential for locating views studies in all publication formats. We discuss some benefits and challenges of utilising different information sources. Copyright © 2013 John Wiley & Sons, Ltd.

Keywords: information retrieval; qualitative research; publication format; bibliographic databases; information sources; public health

1. Background

A key stage in undertaking systematic reviews is objectively identifying research upon which to base an analysis. This process is informed by several factors including knowledge of how research is published (e.g. as a journal article or book chapter) and the media used to identify research, such as different bibliographic databases or websites. Although key skills in information literacy for research include an awareness of the types, characteristics and formats of information within an area of research (Bent *et al.*, 2012), there are challenges in locating research within the field of public health, particularly when looking for studies of people's experiences, opinions and understandings about health issues ('views studies').

Systematic reviews of people's perspectives can play an important role in informing policymaking on health interventions. Such reviews tend to incorporate qualitative data, obtained via open-ended questions, although views data can also be quantitative in form, for example when participants select from a choice of predetermined

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responses. Views studies also vary by the types of views expressed. Brunton *et al.* (2006) developed a typology of seven types of views found within 97 views studies of people's views of walking and cycling for transport: (i) attitudes and opinions (people's beliefs, likes or dislikes); (ii) stated behaviours (what people say they do); (iii) perceptions (descriptions of a situation or experience); (iv) intentions (what people plan to do); (v) experiences (specific episodes that people say happen to them); (vi) knowledge (what people say they know about a situation); and (vii) expectations (e.g. what they would like).

Searching for 'views' studies within public health is particularly challenging owing to variations in the terminology used to describe the research, abstract quality and database indexing (Shaw *et al.*, 2004; Barroso *et al.*, 2003; Evans, 2002). This is confounded by the literature potentially spanning across a range of fields and disciplines, including health, education, sociology and psychology. For reviews of people's perspectives, the nature of publication is also relevant. Qualitative research papers can be relatively lengthy owing to the inclusion of verbatim quotations and contextual description (Walsh and Downe, 2005). As a result, such studies are published as books, book chapters or research reports as well as journal articles. Additionally, it has been suggested that a bias against publishing qualitative research exists in some journals, though this may be lessening (Finfgeld-Connett and Johnson, 2013).

There is a small amount of recent literature evaluating the performance of information resources for primary research in specific public health and education topics (e.g. Clapton, 2010; Ogilvie *et al.*, 2005; Stansfield *et al.*, 2012; Weaver *et al.*, 2002). There is a consensus that searching widely across a range of topic-focused databases is important. It has been suggested that the use of a range of methods to supplement bibliographic database searches, such as internet search-engines and contacting experts, yields a wider range of evidence, as observed by Ogilvie *et al.* (2005) in their review on social interventions for promoting active transport.

There has only been limited study of the information sources used in systematic reviews of views studies (Papaioannou *et al.*, 2009; Pearson *et al.*, 2011; Stansfield *et al.*, 2012). Papaioannou *et al.* (2009) assessed the strategies used to retrieve literature on student experiences of e-learning and demonstrated the importance of using both multiple databases and other methods involving citation searching, reference list checking and contacting authors and experts. A study by Pearson *et al.*, 2011 explored different strategies for rapidly identifying qualitative research relating to cardiovascular prevention programmes and found reference checking more useful than citation checking and contacting authors for supplementing a bibliographic database search. Stansfield *et al.* (2012) found that database selection could influence review findings on the basis of the analysis of a subset of data from a review of children's views of obesity. The studies within that dataset are included as part of the analysis reported here.

Other authors have explored information sources as part of wider analyses of the methods used for reviews of qualitative studies (Bondas and Hall, 2007; Dixon-Woods *et al.*, 2007; Hannes and Macaitis, 2012). Hannes and Macaitis (2012) analysed the methods of 82 reviews of qualitative research in health care published between 2005 and 2008. The databases used for each review were reported in all but five reviews, and between the reviews, over 40 different databases were used. MEDLINE and Cumulative Index to Nursing and Allied Health (CINAHL) were used in over 85% of reviews, and Psycinfo/Psychlit was also popular. Sociological Abstracts, Web of Science (which includes the Social Science Citation Index) and Education Resources Information Center (ERIC) were used in over 10% of reviews. Two earlier studies that analysed the methods of reviews of qualitative synthesis within healthcare (Bondas and Hall, 2007; Dixon-Woods *et al.*, 2007) also found that reviews which reported retrieval had mainly used CINAHL and MEDLINE. Bondas and Hall (2007) observed infrequent use of other databases and little justification for the choice of information sources used. In terms of methods to supplement bibliographic database searches, Dixon-Woods *et al.* (2007) found the most common strategies to be checking reference lists and journal handsearching. Hannes and Macaitis (2012) observed that reference or citation searching were used in over 50% of the studies, and other methods used in some reviews included local or topic-specific search engines, contacting experts and website searching, personal correspondence, related paper searches, email discussion lists, footnote chasing or searching conference abstracts.

Finfgeld-Connett and Johnson (2013) reviewed different methodological approaches to searching in different types of qualitative systematic reviews across healthcare topics. They observed that search methods varied, from having a preset method designed to locate all available research, to iterative sampling approaches that developed throughout the review to provide a suitable sample of research. They identified two challenges in identifying research for reviews: (i) having too many research reports for efficient qualitative analysis (this may occur if the review's focus is too broad or poorly defined) and (ii) obtaining enough research of sufficient depth to answer the research question. It is this second challenge to which our study contributes.

There appears to be little study of the different types of research publication formats (e.g. journal articles, research reports, books and theses) that are included in systematic reviews. Wilson (2009) examined publication format for 11 systematic reviews of effectiveness research published by the Campbell Collaboration in the field of criminology. This study found that 40% of research reports and 50% of books and book chapters were located outside database sources. We are not aware of any studies that look at publication formats for identifying studies of people's perspectives.

2. Aims and objectives

Our aim was to examine the publication format and information sources of research of people's views on three public health issues in order to inform future searching for systematic reviews. The Evidence for Policy and Practice Information and Coordinating Centre (EPPI-Centre) conducted four systematic reviews of people's views across three topic areas: active transport (Brunton *et al.*, 2006), transition to motherhood (Brunton *et al.*, 2011) and obesity (Rees *et al.*, 2013; 2009). All reviews were commissioned to inform UK policymakers. They provided an opportunity to analyse how research on people's views in public health is published and identified.

The characteristics of the four reviews are given in the Appendix. Although the four reviews had some similarities, they differed in terms of specific topic focus, years covered and population. All studies included in each review were included in our analysis if they met the requirements of the review prior to any quality assessment stage. For all reviews, a comprehensive approach was used to identify all potentially relevant studies for each review, balanced by the time and resources available to conduct the review. However, the search methods and information sources were individually tailored to each review. The literature search involved undertaking extensive and sensitive searches on bibliographic databases and 'supplementary information sources', which we describe here as library catalogues, websites of organisations, research centres and search engines, checking reference lists of studies and checking where items have been cited, contacting authors and handsearching journals and conference proceedings. Twenty-two bibliographic databases were searched across the reviews. The database searches used a combination of controlled vocabulary searching and free-text searching of title and abstract fields using many search terms.

During the process of undertaking all reviews, the search results were uploaded into a review management software tool EPPI-Reviewer 3.0, Thomas, 2006), and duplicate citations were removed. The remaining citations were screened for relevance on the basis of their title and abstract, and potentially relevant items were further screened by reading the full-text of the research report. In each review, a large number of studies were identified from the literature search, but only a small proportion of these met the eligibility criteria. This ratio ranged from 0.2 to 2%. A total of 229 studies were included across the four reviews.

Our research questions for this study were as follows:

1. In what publication format were 'views' studies disseminated?
2. How was publication format for the 'views' studies distributed across information sources?
3. How effective was each of the database sources in terms of (i) providing a high yield of studies and (ii) providing unique references not identified in other databases?

3. Methods

For the 229 views studies, we retrospectively determined the publication formats and the information sources from which they were captured. The publication format was identified by manually checking the citation. Data on the information sources were obtained from the review management software. In order to count the records, the data were simplified: (i) we did not include related citations linked to the same study; (ii) two studies published within one citation was counted as one study (this applied to one citation in the active transport review); (iii) studies found in bibliographic databases were treated as if they have not been found in other information sources; and (iv) studies from supplementary information sources were mutually exclusive from each other. These assumptions were made owing to the information management of the literature search results when undertaking the original systematic reviews. (The complete search results from bibliographic databases had been uploaded into the review management software by automation, but many search results from supplementary information sources had been uploaded manually into the review management software after they had been screened for eligibility to a review and where they had not been identified previously from another source).

4. Results

1. *In what publication format are 'views' studies disseminated?*

Table 1 shows the publishing format across all the reviews, using the categories of journal articles, books or book chapters, conference proceedings, theses, and primary datasets. Studies not falling in these categories were grouped as 'research reports'; these reports are often quite technically detailed reports from, for example, research-active non-governmental or charitable organisations and government bodies. Across the four reviews, the majority (61%, $n = 139$) of studies were published as journal articles, and over a quarter (29%, $n = 66$) were research reports. Over half of the remainder (5%, $n = 11$) were reported in other formats. The two primary datasets refer to a website containing research interviews (Health Experiences Research Group, 2010) and an archive of transcripts (Lloyd and Dittmar, 1997).

Journal articles provided the largest proportion of studies across all of the four reviews, but there was a less consistent pattern for the other publication formats. For the review on active transport, research reports were just

Publication format	Total	Individual reviews			
		Active transport	Motherhood	Obesity (young people)	Obesity (children)
Journal articles	61% (139)	46% (50)	83% (50)	72% (23)	57% (16)
Research reports	29% (66)	45% (49)	7% (4)	16% (5)	29% (8)
Books/book chapters	5% (11)	3% (3)	10% (6)	6% (2)	0
Theses	3% (6)	2% (2)	0	0	14% (4)
Conference proceedings	2% (5)	5% (5)	0	0	0
Primary datasets	0.9% (2)	0	0	6% (2)	0
Totals (100%)	229	109	60	32	28

as predominant as journal articles. For the review on motherhood, there was less research published in report form, but 10% ($n=6$) was published in books. Theses were used in two reviews (active transport and obesity and children), and the active transport review contained five papers from conferences.

2. How is publication format distributed across information sources?

Table 2 shows the information sources of the studies and how this varied by publication format. Nearly half of the studies (48%, $n=110/229$) were journal articles found in bibliographic databases. Other good sources of journal articles were websites and reference checking, finding 16 and eight articles, respectively. The journal article obtained by handsearching was obtained from the journal, *Transport Policy*, which was recommended by the review's advisory group and was not indexed well on bibliographic databases. The journal articles were spread across more than 80 different journals.

Both bibliographic databases and supplementary information sources were useful for finding research reports, locating 55% and 45% of reports, respectively. However, the high yield of research reports from bibliographic databases was influenced by the database Transport, which identified 33 out of the 36 reports found in the databases. The other three reports were identified in Social Policy and Practice and Health Promis (a register of the former UK Health Development Agency that is no longer publicly available). Reference checking and citation checking, websites and author contact were also important, identifying a further 18, seven and four reports, respectively.

Most of the books or book chapters included in these reviews were found from websites ($n=6/11$), but two library catalogues [British library and the National Health Service (NHS) Health Scotland library] and two bibliographic databases (Sociological Abstracts and Transport) also contributed. Websites, contacting authors and checking reference lists were successful methods for identifying conference proceedings and primary datasets. One conference was located from the database Transport. The small number of theses ($n=6$) were found from two bibliographic databases that index only theses (Dissertation Abstracts, British Index to Theses), author contact and a library catalogue (British library).

3. How effective was each of the bibliographic database sources in terms of (i) providing a high yield of studies and (ii) providing unique references not identified in other databases?

Publication format	Studies	Database sources	Supplementary information sources
Journal articles	139 (61%)	109	30 found through: websites (16); reference checking, including forward citation checking (9); author contact (3); hand search (1); background (1).
Research reports	66 (29%)	36	30 found through: websites (18); reference checking, including forward citation checking (7); author contact (4); background (1).
Books/book chapters	11 (5%)	2	Nine found through: websites (6); library catalogue (3).
Theses	6 (3%)	3	Three found through: author contact (2); library catalogue (1).
Conference proceedings	5 (2%)	1	Four found through: websites (3); reference checking (1).
Primary datasets	2 (0.9%)	0	Two found through: websites (1); author contact (1).
Total	229 (100%)	151 (66%)	78 (34%)

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Across the dataset, two-thirds of studies (66%, $n = 151$) were located in bibliographic databases. Table 3 shows the number of bibliographic databases in which these studies were found. The majority (73%, 110/151) were found only from a single database, and this pattern was the same across all reviews. The 43 remaining studies were each found in between two and eight databases. In three reviews, over 45% of studies were found from one database only. However, in the obesity and young people review, the proportion of items found in only one database was much less (16%, $n = 5$), and there was more duplication across the databases.

Table 4 shows the databases that served as sources for each review, on the basis of the 151 studies identified from bibliographic database sources. Counting all duplications of items across sources, this added up to a total of 248 citations identified across 19 databases, though not all were searched in the same reviews. For example, Transport and Geobase were only searched in one review as they related to the field of transport; access to EMBASE was limited and this was only searched in one review, though it found 11% of studies in that review. For the active transport review, the database Transport predominated as the chief source of studies. For the other three reviews, there were several sources that provided moderately high yields of citations, and PubMed identified over 12% of citations in each review. The following databases also each yielded over 10% of citations in at least two reviews: Applied Social Sciences Index and Abstracts (ASSIA), CINAHL, Psycinfo and Social Science Citation Index. Sociological abstracts found 8% of citations for the motherhood review but did not identify citations for the active transport and was not searched for the obesity reviews. There was considerable overlap of studies across databases, however, 15 databases provided studies that were not identified elsewhere, depending on the review. PubMed was a source of unique studies across all reviews, and ASSIA provided unique studies across three of four reviews. Psycinfo and CINAHL were sources of unique studies in the motherhood review but not in the obesity reviews. In each review, between two and four databases were searched that did not capture any relevant studies.

In both obesity reviews, Psycinfo, PubMed and the Social Science Citation Index were good sources, each finding from 10 to 20% of the included studies. The distribution of literature among other databases differed between the two reviews (though the numbers are fairly small and EMBASE and Physical Education Index were not searched in the children's review). The scope of the two obesity reviews differed in terms of population and study design (the young people's review only sought qualitative views data). In addition, the search terms and sources used for the young people's views review were informed by knowledge gained from undertaking the earlier children's review. Therefore, as a brief quality check for this comparison, we retrospectively re-ran the search strategies for the two obesity reviews in PubMed to determine if some of the included studies were in PubMed but had not been captured in our search strategies (this method was published by Sampson and McGowan, 2011). PubMed was one of the highest-yielding databases. We found that a journal article (Percy-Smith, 2007) was located in PubMed but had not been captured by the original PubMed search. This was owing to the absence of terms for body size or obesity in the title, abstract or controlled vocabulary fields. However, the study had originally been identified in the British Education Index; here it had been assigned the controlled vocabulary 'body image', a phrase that had been used in our original search. On this basis, we were confident that our approaches for database searching were comparable for the two reviews.

5. Discussion

This analysis demonstrates that research into people's perspectives can be published in a wide range of publication formats such as journal articles, books and research reports. Although the majority of studies are published as journal articles, studies from other publication formats are worth trying to identify. Despite the range of topics, the trends of publication format were largely similar for the reviews, though there were more books or book chapters present in the motherhood review.

Table 3. The number of bibliographic databases in which a study was identified.

No. of databases	All studies ($N = 229$)	Active transport ($n = 109$)	Motherhood ($n = 60$)	Obesity, young people ($n = 32$)	Obesity, children ($n = 28$)
0	33% (78)	34% (37)	33% (20)	44% (14)	25% (7)
1	49% (110)	61% (66)	47% (28)	16% (5)	39% (11)
2	8% (18)	4% (4)	12% (7)	9% (3)	14% (4)
3	3% (8)		7% (4)	6% (2)	7% (2)
4	3% (7)	2% (2)		6% (2)	11% (3)
5	0.4% (2)			6% (2)	
6	0.9% (2)		2% (1)		4% (1)
7	0.4% (1)			3% (1)	
8	0.9% (3)			9% (3)	

Table 4. The number of studies found in bibliographic databases for each review*.

Database	Active transport		Motherhood		Obesity, young people		Obesity, children	
	79 citations of 72 studies		60 citations of 40 studies		66 citations of 18 studies		41 citations of 21 studies	
	Yield (n = 79)	Unique (n = 66)	Yield (n = 60)	Unique (n = 28)	Yield (n = 66)	Unique (n = 5)	Yield (n = 43)	Unique (n = 11)
ASSIA	3% (2)	1	20% (12)	8	11% (7)		7% (3)	1
British Education Index	—		—		8% (5)	2	2% (1)	
Bibliomap	—		—		2% (1)		2% (1)	
CINAHL	—		22% (13)	6	11% (7)		5% (2)	
Dissertation abstracts	0		—		0		2% (1)	1
EMBASE	—		—		11% (7)		—	
ERIC	—		—		2% (1)		2% (1)	1
Geobase	9% (7)	2	—		—		—	
Health promis	—		—		2% (1)		5% (2)	
HMIC	3% (2)	1	—		—		—	
IBSS	6% (5)	4	8% (5)		5% (3)		12% (5)	1
Index to Theses (British)	—		0		0		5% (2)	2
Physical Education Index	—		—		8% (5)	1	—	
Psycinfo	—		17% (10)	8	14% (9)		17% (7)	
PubMed	6% (5)	3	20% (12)	5	12% (8)	1	20% (8)	3
Sociological Abstracts	0		8% (5)	1	—		—	
SPP	—		5% (3)		6% (4)	1	7% (3)	2
SSCI	—		—		14% (9)		17% (7)	
Transport	73% (58)	55	—		—		—	

ASSIA, Applied Social Sciences Index and Abstracts; CINAHL, Cumulative Index to Nursing and Allied Health; ERIC, Education Resources Information Center; HMIC, Health Management Information Consortium; IBSS, International Bibliography of the Social Sciences; SPP, Social Policy and Practice; SSCI, Social Science Citation Index.

*a hyphen denotes that the database was not searched.

For all four reviews examined, the majority of research was either captured from a single database only or from supplementary information sources. It is clearly important to search the topic-focussed databases, where available, as in the case of Transport for the active transport review. Out of the large databases focussed on health or social sciences, none predominated in providing high yields of studies, but most identified some studies that were not found elsewhere. Nineteen bibliographic databases contained the 151 studies, and it appears that there is a large overlap between these databases concentrated on a small number of studies. The remaining studies found only on one database were dispersed widely throughout 15 databases and supplementary information sources. Furthermore, we found unique studies in PubMed and across social science databases for all four reviews. Education databases may sometimes provide studies not found elsewhere, though were not searched for two of the reviews studied here. Differences in database indexing mean that it can be useful to search a range of databases that contain similar research citations. Therefore, it is essential that a range of databases are searched covering health and social sciences and a range of publication formats when seeking 'views studies' in public health topics.

The search strategy for the review on obesity young people was informed from the experiences of the earlier review on obesity and children. The later review searched two additional databases, and 48 websites and eight library catalogues compared with 16 websites and two library catalogues in the children's review. This may explain the higher proportion of studies found outside database sources in the obesity and young people's review.

Although the majority of journal articles tend to be identified from databases, some were also identified through supplementary information sources, particularly websites and reference checking. With the 139 journal articles dispersed in more than 80 journal titles, such additional searching is important. Supplementary information sources were found to be particularly useful for finding publication formats less common within some bibliographic databases (conference proceedings, research reports, books and theses). It is important to be aware that some large databases are selective with certain publication formats, for example, PubMed indexes journals and some online books. It is therefore important for literature searchers to understand the type of literature that is present within specific databases and other sources in which research of potential relevance can be found.

In a study of 11 effectiveness reviews in criminology, Wilson (2009) found that 3% of journals, 41% of research reports, 11% of theses and 50% of books and book chapters were located outside of databases sources. The

trends are broadly comparable with our own findings within systematic reviews of views studies from public health topics. This could indicate that such findings apply to a range of study designs of primary research and across subject disciplines.

Our findings on the ratio of studies found within and outside databases follow a similar pattern to those found by Papaioannou *et al.* (2009). These researchers found 73% ($n = 30$) studies of 'views research' dispersed across 10 databases in their topic area of adult student e-learning. In their study, the remaining 27% ($n = 11$) studies were from methods other than bibliographic database searching, and they also found that a large portion of studies found outside the bibliographic database searches were higher quality.

The choice and extent of utilising multiple bibliographic databases and supplementary sources may differ in practice according to the need and resources available, as illustrated between the four reviews under analysis. The two reviews on obesity utilised the most bibliographic databases to find a small pool of studies. Less bibliographic databases were used for the review on motherhood, but over 30 000 references were identified (though this included both UK and international literature), to provide 60 UK studies of relevance to the review, and a smaller subset was analysed in more detail for the review. For the review on active transport, a large number of studies were initially identified from a range of bibliographic databases to develop a broad map of the research, and supplementary searches were undertaken after the research focus was narrowed to one area of research.

There are challenges to utilising different information sources, for example, searching for books in library catalogues is different to searching for a journal article in a bibliographic database. The book *Health Issues and Adolescents* (Shucksmith and Hendry, 1998) was found during a literature search using simple search of 'body' AND 'adolescence' (in the NHS Scotland library catalogue) but would require the much broader search of 'health and adolescence' to be identified in the Institute of Education's library catalogue. However, retrospectively rerunning the search, 3 years on, it is difficult to reproduce the search and obtain the same result in the NHS Scotland library catalogue. The difficulty in locating books that contain primary research on views studies raises the question of which studies in books have been missed and whether more efforts should be used in seeking out these types of studies. Barroso *et al.* (2003) searched extensively for books and scanned the physical library shelf locations of books found to be useful, in order to find other books that might be of interest. They found 3% ($n = 3/114$) of studies published as books or book chapters (Sandelowski *et al.*, 2004). A particular barrier to using books is their availability and the time involved in ordering any that are not readily available; although this issue might sometimes be encountered for other publication formats too. Overall, a number of issues need to be considered in seeking out relevant studies published outside journal articles: (i) searching multiple sources (including relevant bibliographic databases); (ii) the iterations and words used for the search; and (iii) whether the effort is of benefit to a review in terms of time and resources.

A further aspect of publishing is the type of research that is published within a particular format. For example, sociological issues such as motherhood tend to be lengthy discussions more suited to book publication, and we speculate that PhD theses within the sociological sphere might particularly receive funding to be published as books, in contrast to other disciplines. Dunleavy (2012) reported the findings of a study of UK social scientists and citation to their outputs in terms of publication and discipline. Across 12 disciplines within social science, they found that just over three-fifths were journal articles and a fifth were books, book chapters or edited books. Research within the fields of economics and psychology was eight times more likely to be cited from a journal article than a book, but in sociology and media studies, this ratio was reduced to 2:1. For reviewers, undertaking reviews on different topics such publishing nuances and practices embedded within an academic discipline may be lost, and consulting topic experts could help with this.

The strengths of this study are that it illustrates where potentially relevant UK views studies in public health might be found and demonstrates how the research might be published. It is unique in drawing comparisons across several reviews on different topics and adds to the paucity of literature on the contributions of different publication formats and the contributions from different databases. As the authors were directly involved in the reviews used in the analysis, it was possible to check queries and return to the raw data when undertaking the analysis. A potential limitation is that many items found from the database searches might also be found from the supplementary sources; however, for analysis purposes, we assumed that items were either present in a database or from supplementary sources owing to our data collection during the review process. Comparison between individual supplementary sources is approximate, as it depends on the order in which they were searched (studies from these sources were only captured when they had not been found previously). Therefore, the estimate of the contribution of each supplementary source is a minimum and is probably much higher in reality.

6. Conclusions

This study helps inform the methods of searching for future reviews of people's perspectives on public health. It is clear that studies of views in public health are published in a range of formats and that a variety of information sources need to be utilised to locate this kind of research including both multiple bibliographic databases and supplementary information sources. However, utilising supplementary sources require a range of different

techniques and raises additional, particular challenges. Furthermore, the disciplines relevant to a topic may potentially have an impact on how the item can be found as a result of how it is published.

APPENDIX

CHARACTERISTICS OF THE FOUR REVIEWS USED IN THIS ANALYSIS

Topic, reference and funding	Population, timeframe	Number of studies	Search methods	Conceptual themes searched for within the bibliographic databases	Precision of search (studies in review/studies retrieved)
Active transport (walking and cycling for transport), Brunton <i>et al.</i> (2006). Funded by the Department of Health (England)	Children, young people, parents 1995–2005	110 (in 109 reports) of which 97 studies in a map, plus 13 from additional searches	Three-stage approach: (i) locating systematic reviews from review registers and websites; (ii) locating primary research in bibliographic databases; and (iii) at in-depth stage of review: reference checking, forward citation searching, contacting authors and handsearching two journals	Walking and cycling AND health promotion AND views/qualitative study designs AND UK	Mapping stage 1.50% (97/6484)
Motherhood (becoming a mother), Brunton <i>et al.</i> (2011). Funded by the Economic and Social Research Council	Women 1975–2009	60 in map	One-stage search to locate literature internationally, followed by searching within this to obtain UK literature	Mothers AND motherhood AND transition AND views/qualitative study designs	Mapping stage 1.97% (60/30 400)
Obesity, Rees <i>et al.</i> (2009). Funded by Department of Health (England)	Children 1997–2008	28	One-stage search	Population AND obesity AND views/qualitative study designs	0.35% (28/8029)
Obesity, Rees <i>et al.</i> (2013). Funded by Department of Health (England)	Young people 1997–2010	32 (additional four studies were also in the review on obesity and children, but they are not counted here)	One-stage search	Population AND obesity AND views/qualitative study designs AND UK	0.20% (32/18 365)

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Research Article

Identifying Social Care Research Literature: Case Studies From Guideline Development

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Abstract

Objective – Systematic searching is central to guideline development, yet guidelines in social care present a challenge to systematic searching because they exist within a highly complex policy and service environment. The objective of this study was to highlight challenges and inform practice on identifying social care research literature, drawing on experiences from guideline development in social care.

Methods – The researchers reflected on the approaches to searching for research evidence to inform three guidelines. They evaluated the utility of major topic-focused bibliographic database sources through a) determining the yield of citations from the search strategies for two guidelines and b) identifying which databases contain the citations for three guidelines. The researchers also considered the proportion of different study types and their presence in certain databases.

Results – There were variations in the ability of the search terms to capture the studies from individual databases, even with low-precision searches. These were mitigated by searching a combination of databases and other resources that were specific to individual topics. A combination of eight databases was important for finding literature for the included topics.

Multiple database searching also mitigates the currency of content, topic and study design focus, and consistency of indexing within individual databases.

Conclusion – Systematic searching for research evidence in social care requires considerable thought and development so that the search is fit for the particular purpose of supporting guidelines. This study highlights key challenges and reveals trends when utilising some commonly used databases.

Introduction

As people are living longer with more complex conditions, there is a need for a more integrated health and social care system. In 2012, the National Institute for Health and Care Excellence (NICE) in England broadened its remit on health to develop national quality standards and guidelines for social care. The NICE Collaborating Centre for Social Care was set up in 2013 and has addressed cross-cutting themes spanning health and social care through the provision of guidelines. Social care "generally refers to all forms of personal care and other practical assistance for children, young people and adults who need extra support" (NICE, 2014, Glossary). The NICE guidelines contain recommendations for individual health and social care practitioners, local authorities, health and social care commissioners, providers of services, and other organizations (NICE, 2014). The procedures for developing social care guidelines were informed by the processes used for clinical guidelines. Guideline committees develop the guidelines and are supported by evidence review teams, who undertake systematic literature searches and review the best available evidence (NICE, 2014).

Both health and social care service fields contain complex systems, and there are similarities in reviewing research evidence in these areas. However, as part of developing social care guidelines, important differences in the respective research traditions meant that reviewers and information scientists in the new collaborating centre had to consider whether a unique approach was needed. The purpose of this study is to focus on lessons learned from the systematic searching undertaken to support the evidence reviews that inform the development of guidelines. Drawing on analyses of three searches for social care guidelines, we describe some challenges and reflect on the utility of these searches. The three guidelines focused on social care support for people across three distinct topics: 1) home care—delivering personal care and practical support to older people living in their own homes (NICE, 2015); 2) transition between inpatient mental health settings and community or care home settings (NICE, 2016b); and 3) transitions from children's to adults' services for young people using health or social care services (NICE, 2016a). The latter two guidelines also covered support for people using health services.

Literature Review: The Peculiarities of Searching for Social Care Research

Challenges of seeking diverse literature for guidelines have been recognised in public health (Levay, Raynor, & Tuvey 2015). Like public health, social care sits in between other services by its very nature and purpose. This is reflected in the research literature, which uses a diverse terminology and is published within a range of disciplines, such as social sciences, health, criminal justice, and housing (Clapton, 2010). The literature is varied in format, with reports and unpublished literature making up a significant proportion (Clapton, 2010). To account for this, Golder, Mason, & Spilsbury (2008) suggest

searching a number of different sources that cover different disciplines and using broad search strategies that encompass many variants of terminology. A number of case studies in this field recommend that social care systematic reviews utilise databases drawn from the broad fields of health, social sciences, and social care or those that contain multidisciplinary sources (Brettell & Long, 2001; Clapton, 2010; Golder et al., 2008; McElhinney, Taylor, Sinclair, & Holman, 2016; McFadden, Taylor, Campbell, & McQuilkin, 2012; McGinn, Taylor, McColgan, & McQuilkin, 2016; Steventon, Taylor, & Knox, 2016; Taylor, Wiley, Dempster, & Donnelly, 2007; Taylor, Dempster, & Donnelly, 2003). Clapton (2010) found that a minimum of seven or eight databases needed to be searched to capture the relevant references for three reviews on looked-after children (children under care), and the exact selection of databases is highly dependent on topic. McGinn et al. (2016) show that it is difficult to predict the best databases across several social care topics. National context is also important. The reviews studied by Clapton (2010) informed a UK context, and she suggests searching UK-focused databases to add local context and reduce North American bias from commonly used databases.

Developing search strategies to capture the diverse terminology and research literature within social care literature is therefore a challenge. Steventon et al. (2016) considered approaches for a search about risk communication and risk concepts in dementia care. They found that *care* as a concept was too diffuse as it encompassed location of care, types of carer, range of professionals involved in care, specific care services, quality of care, service policy, and practice issues. Golder et al. (2008) observe that alternatives for the term *carer* include phrases such as *husbands supporting their wives* or *children caring for their elderly relatives*, and there may be specific terms for paid and unpaid staff, (e.g., *care worker* or *volunteer*). They also note national differences, whereby the term *carer* is common in the United Kingdom, but *caregiver* or *caretaker* are terms used in the United States.

Given that social care research is considered difficult to identify, it is of interest to assess how well systematic searches locate what is present within a database. A thoughtful search strategy "considers the aim of searching, ensuring that the appropriate methods are used; what the most relevant sources of studies are likely to be; the benefits and drawbacks of searching each source; the resources available; ... appropriate search terms; and the benefits and costs of different combinations of sources within the available resources" (Brunton, Stansfield, Caird, & Thomas, 2017, p. 105). The case studies referred to above are based upon analysis of search results to assess which studies were identified from which database. While these findings help to indicate a database's usefulness to individual topics, they depend on the search strategies used.

More informative is the analysis by Golder et al. (2008) for a review on the effectiveness of respite care for carers of frail older people. They found that for the majority of databases their search strategies failed to retrieve some relevant references that were stored in these databases, despite using a very broad search. Reasons were that the bibliographic details lacked one of the concepts in their search, one of the concepts was expressed using ambiguous phrases, or records did not contain abstracts. They found that the studies from their review could be identified using their search strategy on six databases (AgeLine, EMBASE, Health Management Information Consortium (HMIC), MEDLINE, PsycINFO, Social Sciences Citation Index (SSCI)) plus reference checking and contacting authors. They checked which databases contained these studies and found that the same six sources collectively contained all the included references. The search strategy used in their systematic review identified unique references (i.e., items found from only one of the resources searched) in four databases: AgeLine, EMBASE, PsycINFO, and SSCI. The authors found that reference checking and contacting authors are also valuable sources of unique relevant references and provide materials not available through the use of databases.

A similar investigation by Bayliss & Dretzke (2006) found that in seven out of nine databases investigated, their searches failed to locate relevant studies that were present for a technology assessment report on a parenting intervention. Reasons included: the bibliographic details lacked either the study design or subject elements used in their search, the index terms searched, and the absence of abstracts. The difficulty of missing items is not limited to social care. In analyzing the citations of nine systematic reviews of diagnostic test accuracy, Preston, Carroll, Gardois, Paisley, & Kalthenthaler (2015) found 11% of citations were indexed in either MEDLINE or EMBASE but were not retrieved by the searches used for each review. We are aware that search strategies can never be perfect and will never retrieve every relevant reference (Brettell et al., 1998, Brunton et al., 2017, p. 98), and other constraints include the time and resources available to search (Brunton et al., 2017, p. 97). While the balance between sensitivity and precision in systematic searches needs to be grappled with across various research fields, we suggest social care searching merits further investigation, based on the literature reviewed here and our own experiences of working on social care guidelines as well as systematic reviews in health and education.

Aims and Objectives

This study aims to draw on the experiences of identifying social care research for three guideline topics in order to highlight challenges and inform practice. We write from the perspectives of an information scientist charged with designing the searches based on the scope of the guideline and a reviewer charged with screening citations and appraising included studies. We hope that by analyzing the utility of our own approaches we can share knowledge on how social care searching can be developed further. Specifically, our objectives are to:

- a) reflect on the challenges of searching for three guideline topics; and
- b) evaluate the utility of major topic-focused bibliographic database sources for identifying research.

Methods

Overview of the Approach to Literature Searching for the Three Guidelines

Each guideline was preceded by a referral to the NICE Collaborating Centre for Social Care, based on a population need identified through policy and practice. This referral was developed into a scope following consultation with stakeholders. The scope outlines the importance of the topic and the remit of the guideline in terms of populations, settings, and interventions. As part of developing the guidelines, each topic contains approximately seven sets of research questions relating to the effectiveness of interventions, people's experiences of them, and barriers and facilitators to service delivery or interventions. Table 1 provides examples of each type of research question for each topic.

Each literature search utilized over 20 bibliographic databases comprising international and UK-focused health, social science, social care, and economic databases. The searches were supplemented by mainly UK-focused website searches, specialist registers, and catalogues, some citation searching, and contributions from the guideline development team. The search resources differed across the three topics, and the analysis presented here focuses on general databases in health, economics, social sciences, and social care. The full search strategies and reviews are reported elsewhere (NICE, 2016a, 2016b, 2015). The original database searches were updated after one year to identify new research on the effectiveness of

interventions. The searches were followed by screening and appraising studies for relevance to the review questions. Studies deemed relevant to the review questions were then included to inform recommendations within the guidelines.

Table 1 Examples of Types of Research Questions for Each Guideline

Types of research questions	Guidelines		
	Home care: delivering personal care and practical support to older people living in their own homes	Transition between inpatient mental health settings and community or care home settings	Transition from children's to adults' services for young people using health or social care services
Effectiveness of the interventions	What approaches to home care planning and delivery are effective in improving outcomes for people who use services?	What is the effectiveness or impact of interventions, components of care packages, and approaches designed to improve discharge from inpatient mental health settings?	What is the effectiveness of interventions designed to improve transition from children's to adults' services?
People's experiences	What are users' and family carers' experiences of home care?	What are the views and experiences of people using services in relation to their admission to inpatient mental health settings from community or care home settings?	What are young people's experiences of transitions? What works well?
Barriers and facilitators to specific interventions	What are the significant features of an effective model of home care?	How do different approaches to assessment, care planning, and support (including joint working) affect the process of admission to inpatient mental health settings from community or care home settings?	What factors help and hinder purposeful and planned transitions from children's or adolescents' to adults' services, as identified by young people, their families and carers, practitioners, and research?

Table 2 Databases Searched and the Database Platform

Database	Platform
British Education Index (BEI), CINAHL Plus, Econlit, ERIC, MEDLINE	EBSCO
British Nursing Index (BNI)	HDAS
AMED, EMBASE, MEDLINE, PsycINFO, Health Management Information Consortium (HMIC), Social Policy and Practice (SPP)	Ovid
ASSIA, ERIC, International Bibliography of Social Sciences (IBSS), Library and Information Science Abstracts (LISA), PAIS, PILOTS, Sociological Abstracts, Social Services Abstracts, Worldwide Political Science Abstracts (WPSA)	Proquest
Social Sciences Citation Index (SSCI)	Web of Science

Methods of Analysis

The search protocols and key internal documents related to developing the search strategies for each guideline were revisited. Common challenges were identified, and key ways to address these were noted.

A three-step process was used to investigate the utility of database sources. First, for two of the guidelines (child to adult services and mental health setting transitions) the citations used to provide research evidence were traced back to their original sources. These two guidelines contained 81 and 71 citations, respectively. The citations were checked against the original search results prior to duplicate checking and prior to the update searches. For the homecare guideline, citations located outside databases were also investigated. Second, the presence of the 225 citations from all three guidelines was checked in 20 major topic-focused bibliographic databases at least one year after the original searches. This was undertaken by searching the fragments of titles for each citation. Databases hosted within the same platform were searched together and are listed in Table 2. These include many of those that had been searched for each topic plus some additional databases. These databases were selected for being important topic-focused databases and convenience of analysis. Third, the sources of the original searches and the studies present within the databases were compared for two guidelines, and we observed some reasons for disparities across selected citations.

Analysis was undertaken using the systematic review management tool, EPPI-Reviewer 4 (Thomas, Brunton & Graziosi, 2010). EPPI-Reviewer 4 is a web-based electronic software for managing systematic reviews that is based on hundreds of reviews supported by or conducted at the EPPI-Centre (<http://eppi.ioe.ac.uk/cms>). It facilitated the assigning and analysis of codes for each citation relating to review questions, study designs, and databases.

Results

Designing the Search Strategies for the Three Guidelines

As part of the guideline development process, the information scientist developed searches that aimed to be sensitive in retrieving most of the studies available but balanced with retrieving a manageable number

of citations to screen. As the guidelines were led by a stringent timeframe, comprehensiveness of searches needed to be balanced with the time available to complete the reviews, which included the reviewers' need for time to screen and review studies. The number of records screened from the database searches ranged from around 14,500 to 21,400 per topic, after removal of duplicates. The number of citations of studies that were used to inform each guideline ranged from 71 to 81 per topic, which equates to an individual search precision of under 0.6%.

Table 3 Common Challenges and Selected Examples Across the Guidelines

Challenges	Guidelines		
	Homecare for older people	Transition between mental health inpatient and community settings	Transition from children's to adults' services
Population encompasses individuals to organizations or settings	Individual homecare staff and social care agencies	Individual patients returning home and service transitions such as secondary care to primary care	Young people transitioning and children's and adult health and social care services
Some relevant controlled vocabulary have broader focus than the topic and some MeSH term examples	Home nursing	Discharge Continuity of patient care	Patient transfer Continuity of patient care Patient care planning
Irrelevant studies retrieved in test searches	Clinical studies on home nursing in medical databases	Studies on prevalence or characteristics of the population	Transition has multiple meanings (e.g., physical and emotional development; life change transitions, such as parenting, education and employment)

Table 3 summarizes, with selected examples, some of the challenges in developing a search strategy. A particular challenge for the guideline topics described here was that their titles and referrals did not follow a traditional PICO structure (population, intervention, comparator, outcome), and neither did many of their questions. Most notably, no topic operated with specific outcomes for the interventions and all included open-ended questions. To address this, the information scientist aimed to work closely with the reviewers to clarify ambiguous aspects of the scope and the review questions. For each guideline, the concepts common to each review question, such as populations and setting or context, were identified. In these instances, it was possible to construct one literature search to address the review questions for each guideline topic. A diverse range of search terms were needed for each concept and developed from several test searches.

Across all topics, the population concept encompassed various groups of individuals and organizations. For example, the *population* concept in the homecare topic included older people, homecare staff, carers, social services, or integrated services. For the mental health setting transitions topic, the population was informed by the setting; it included people who were either entering or leaving inpatient mental health settings. Relevant literature might describe the population in terms of people with a mental health disorder and indicate that they are in hospital, or it might describe the mental health unit.

A second concept was used in each topic. For the two topics on transitions, this involved a setting element (such as discharge from hospital to home or moving to adult services), but it also involved a process of transition and included interventions, such as transition planning or treatment education. For homecare, this concept related to the setting and intervention (e.g., care in the home). Articulating this second concept was challenging for all topics owing to the diversity of terminology present in relevant literature.

There was also a problem of context. In the topic on child to adult services, the focus was on care transitions in both in health and social care services. However, *transition* is also a term used to describe facets outside this focus. For example, it can mean transition in terms of adolescent physical and emotional development or life changes, such as parenting, educational achievement, and employment. As some literature about education and developmental transitions is interlinked with research on care transitions, the former topics could not be automatically excluded from the search. To help counter this, a broad range of qualifying terms was used in the free-text searches so that transition had to appear with terms that were indicative of care or transition planning (e.g., care, pathways, readiness, failures, or schemes). Where possible, proximity searching was used, which involved deciding on an arbitrary distance of words between transition and other relevant search terms. For this topic, we decided not to search education databases, but we searched and browsed UK government websites related to the education system for relevant research relating to health and social care service transitions.

The focus of transition between two settings or inpatient mental health settings and community was particularly challenging to articulate. As well as discharge, admission, or transition, there could be a variety of ways to describe the process, such as a person leaving hospital, moving home, returning to the community, or receiving aftercare services. There could also be a change of service provider, such as moving between primary and secondary care. A range of free-text and controlled terms was used to capture this literature for individual and service level transitions in a focused way.

Some relevant controlled vocabulary terms tended to have broader focus than the topic. For example, the Medical Subject Heading (MeSH) term *Continuity of Patient Care* was used in both transitions topics. Controlled vocabulary focused on transitions to services is usually absent. The MeSH term *Transition to Adult Care* was introduced in 2012. To identify earlier literature, the MeSH terms *Continuity of Patient Care*, *Patient Handoff*, *Patient Transfer*, and *Patient Care Planning* were each used in combination with MeSH terms for children and adolescent services. To increase search precision, the MeSH term *Patient Care Planning* had to occur with the term *Adult* in the title or abstract.

All searches retrieved large numbers of irrelevant studies, and we took steps to reduce this. For mental health setting transitions an inclusive study design filter was used in databases that yielded very large search results to capture trials, cost-effectiveness and qualitative studies, and research on people's views or opinions on services. The purpose for using the filter was to reduce the yield of studies on prevalence or describing specific characteristics of the population. We decided to search the education databases

British Education Index and ERIC using a focused search that aimed to capture studies on students returning to school following time in hospital without capturing literature about educational transitions. One particular difficulty that could not be resolved in the homecare topic was being unable to distinguish between clinical studies and social care in large health databases. The MeSH term *Home Nursing* was relevant to the homecare topic but also captured clinical aspects of homecare beyond the guideline focus. For the child to adult services topic, we initially considered using recently published systematic reviews to avoid duplication of effort, but this was not possible during the searching and screening stages as the existing reviews we found did not fully cover a group of interest or some aspects of interest for that group. For example, while there was good coverage on effectiveness and views in some health settings, this material did not provide evidence on related areas, such as barriers and factors to specific interventions. There also seemed to be a gap in reviews on social care transitions for young people with physical disabilities. In compiling the evidence for the guideline, once screening had taken place, some findings of systematic reviews were considered collectively where appropriate.

It was important that appropriate database and website sources were searched to reflect the range of sectors, settings, and outcomes within the scope of each individual guideline. We supplemented database searches by browsing searching on websites for different population groups.

Table 4 Citations Found From the Systematic Review Searches for Two Guidelines

Database	Child to adult services n=81, % (number unique)	Mental health setting transitions n=71, % (number unique)
ASSIA	14	14
BNI	20 (1)	17 (3)
CENTRAL	1	34
CINAHL	30	n/a
CINAHL Plus	n/a	38 (1)
DARE	2	0
Econlit	0	0
EMBASE	41 (1)	44
ERIC	n/a	1 (1)
HMIC	5 (2)	14
IBSS	1	3
MEDLINE	48 (5)	59 (3)
NHS EED	0	3
PsycINFO	35 (5)	56 (2)
SSCI	40 (1)	44 (2)
SPP	31 (7)	11 (2)
Social Services Abstracts	2	3
Social Work Abstracts	0	0
Sociological Abstracts	1	0
ZETOC	n/a	4 (1)
NSPCC Inform	4	n/a
Other sources (unique)	14 (websites, trials registry, early scope work)	6 (citation searching, trials registry, websites)

One way to manage the time needed to conduct the evidence reviews was to only include studies published after a particular date. These varied across the guideline topics and for individual questions. Individual evidence reviews were sometimes limited to the UK context. Decisions on such restrictions were in agreement with the Guideline Committee for that topic, were used where deemed appropriate for a specific reason (such as changes in practice), and were used after searching and screening had taken place. The actual searches were carried out at the farthest time point and not limited by geography. Language exclusions were applied within the databases as the final step in the search for two topics so that the number of citations prior to this exclusion was transparent.

References Identified by the Search Strategies for Two Guidelines

Table 4 shows the yield of relevant citations identified from each resource using the systematic searches for the child to adult services and the mental health setting transition topics. Nearly all the databases searched yielded some studies, and comparing both topics, performance was similar for most of the databases. Notable differences are CENTRAL (the Cochrane trials database), which was much higher yielding for the mental health setting transitions topic, and Social Policy and Practice (SPP), which was higher yielding for the child to adult services topic. EMBASE, MEDLINE, and SSCI each yielded over 40% of the citations for the child to adult services topic. For the mental health setting transitions topic, PsycINFO and MEDLINE, perhaps not surprisingly, yielded over 55% of studies. Social Work Abstracts and Econlit did not yield any studies. Some studies were only found in one database, and these databases differed between the two topics.

Considering the contribution of databases collectively, the following eight databases yielded 89% (135/152) of studies: British Nursing Index (BNI), CINAHL, EMBASE, HMIC, MEDLINE, PsycINFO, SPP, and SSCI. The remaining studies were found from sources outside the databases listed, plus one study for each topic was found from focused searches of ERIC and ZETOC. Sources outside bibliographic databases were important for identifying a small number of studies not located elsewhere, yielding 14% of citations for child to adult services and 6% of studies for mental health setting transitions. This contrasts with the homecare topic where 23% were found from sources outside bibliographic databases.

References Present Within the Databases for Three Guidelines

Table 5 shows the number of studies present in each database for the three guideline topics. The majority of studies were present within these databases. Individual databases containing the most studies varied by topic. For child to adult services, SSCI, CINAHL, and EMBASE each contained 52% of studies, or 70% collectively (n=57/81). For mental health setting transitions, PsycINFO contained 90% of studies (n=64/71), and for home care, SPP contained 77% of studies (n=56/73). A large amount of overlap exists across the databases. Meanwhile, 10% (n=23/225) of studies were located only in one of the databases searched. The majority (8%) of these were from SPP, plus two citations from HMIC, and one from EMBASE. Some citations were not present in any of the databases searched for the child to adult services (7%, or six citations) and homecare topics (4%, or three citations). Twelve citations were found only in one place. Of these, 10 were from SPP, and two were from HMIC.

For the child to adult services topic, the minimum combination of databases to get all of the citations was EMBASE, SPP, and PsycINFO. For mental health setting transitions the combinations were less clear, owing to large overlap between the databases. For the homecare topic, CINAHL Plus, HMIC, and SPP collectively yielded all the studies present within the databases. For all of the topics, seven databases

provided 96% (n=215/225) of citations (CINAHL Plus, EMBASE, HMIC, MEDLINE, PsycINFO, SPP, and SSCI). ERIC yielded one unique study, and the remaining nine studies were not present in any database.

Table 5 Citations Present in Each Database for the Three Guideline Topics

Database	Child to adult services, n=81 % (number unique)	Mental health setting transitions, n=71 % (number unique)	Homecare, n=73 % (number unique)
AMED	4	11	7
ASSIA	19	24	27
BEI	2	1	0
BNI	23	30	14
CINAHL Plus	52	65	53
Econlit	0	0	1
EMBASE	52 (1)	79	30
ERIC	9	4 (1)	0
HMIC	11	23	62 (4)
IBSS	1	4	15
LISA	0	0	1
MEDLINE	51	77	32
PAIS	5	0	1
PILOTS	0	1	0
PsycINFO	41	90	22
Sociological Abstracts	1	0	8
SSCI	52	77	34
Social Services Abstracts	7	8	18
SPP	43 (9)	21	77 (8)
WPSA	0	0	0
Not present in any of these databases	7	0	4

One of the main differences between health research and social care is that in health the concept of *intervention* is well established, and the randomised controlled trial (RCT) is the gold standard for investigating the role an intervention can play in service delivery. In clinical guidelines focussing on drug interventions, the RCT is central and searches on these topics may include methods filters. These filters exclude studies that do not meet established standards for health research, thus increasing the precision of searches. In social care, less work is done on interventions as such.

Instead, many studies investigate approaches and ways of working, and the role of the RCT is less prominent. Therefore, considering which study designs were found in which database is relevant (Figure 1). Four databases yielded over three times more studies on people's views and experiences than on effectiveness (ASSIA, BNI, SPP, and HMIC). CINAHL Plus and SPP provided the most studies about people's views. Studies evaluating cost effectiveness formed a very small portion of studies, and these were present in most of the databases. For Figure 1, some of the studies had overlapping categories, and the *Other* category relates to studies concerning factors that help or hinder an intervention and that do not fit within other study designs.

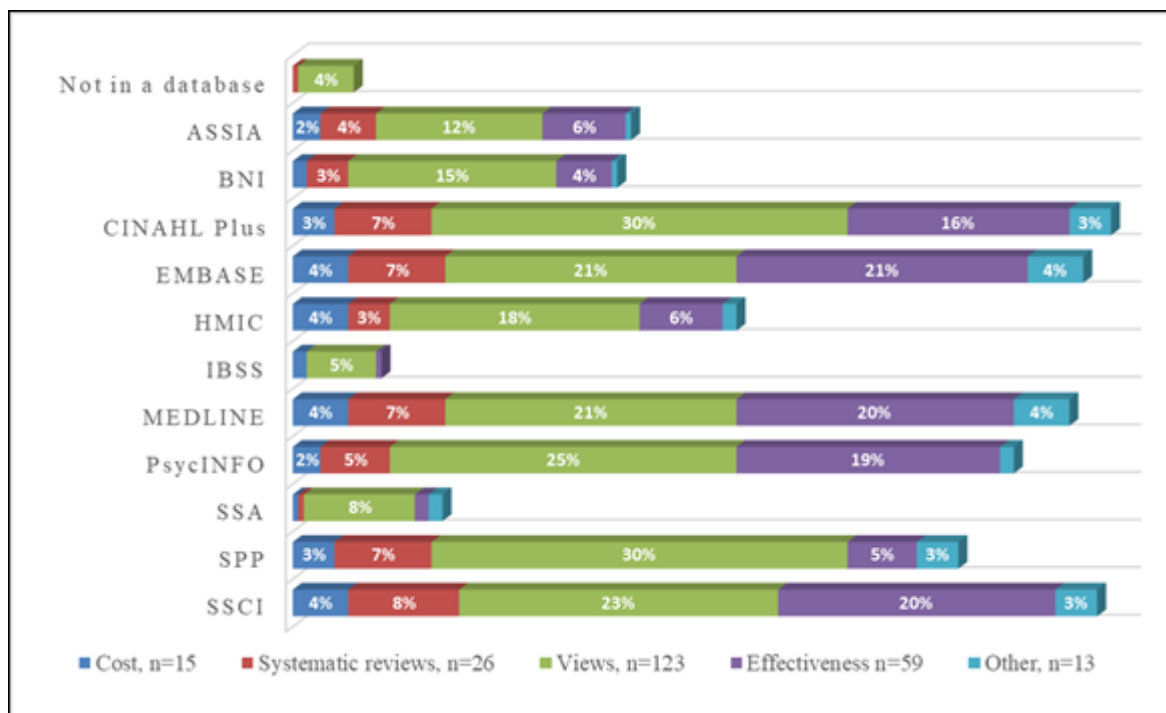


Figure 1 Citations present within each database for different study designs, % of total, N=225 (values under 2% are not annotated).

Table 6 Sources Present Within Selected Databases by Study Type

Study design N=225	Cost n=15	Systematic reviews n=26	Views and experiences n=123	Effectiveness n=59	Other n=13
Total number of citations retrieved by combination	CINAHL Plus, HMIC, and either EMBASE or MEDLINE 100% (15)	SSCI, PsycINFO, and SPP 96% (25)	CINAHL Plus, HMIC, SPP, and SSCI 92% (113)	CINAHL Plus, EMBASE, SSCI, and SPP 100% (59)	Either EMBASE or MEDLINE, and SPP 100% (13)
Not present in a database	-	1	8	-	-

Table 6 provides a matrix of database sources and study designs to help visualize where certain types of studies are located. We recognize, however, that due to database overlap other possible combinations could yield the same studies. The data for Table 6 was compiled using the highest yielding databases for a study design, and the databases where the unique citations were found.

Comparing the Performance of the Databases Searches

Anyone who has conducted complex searches across multiple databases is aware of the curiosities encountered at times due to spelling mistakes in the original title or abstract or due to indexing interpretation. Unpicking every thread of idiosyncrasy encountered across these searches would be extremely time consuming, but a selective picture of why some citations were not located by the search in some databases was gained for the child to adult services and the mental health setting transition topics. The reasons some studies were not located often applied across several databases.

Some studies were not present in the database due to the time lag of adding publications to a database. From our estimates, this is less concerning for citations from BNI, HMIC, and MEDLINE, which each had two items missing due to this issue. The database with the largest time lag issue was EMBASE (18 citations), followed by CINAHL Plus and SSCI (10 citations each).

Controlled vocabulary and keywords within individual databases were important for finding some citations, and this was sometimes the reason a citation present in multiple databases was identified by our searches only in one place. For example, one study present in eight databases was found in only SSCI due to the citation containing the word *transition* in the keyword plus field. The benefit of controlled vocabulary is not consistent within databases. For example, our searches in PsycINFO found two citations for the mental health setting transitions topic, owing to the subject headings *Psychiatric Hospital Admission* and *Psychiatric Hospitalization*. The citations were both present in MEDLINE and SSCI but not located by the search strategy. Conversely, a study indexed in MEDLINE with the MeSH term *Psychiatric Hospitals* was not found using the subject headings within PsycINFO.

Some citations, found in databases elsewhere, were missed owing to controlled vocabulary and indexing being broader than our search strategy. For example, three studies were not found in HMIC because our population terms in the controlled vocabulary were more specific than that applied by the indexers. We opted not to use the controlled term *Transitional Programs* in CINAHL owing to its broader scope than our focus. In SSCI, three studies were not found due to filtering out studies focused on education without containing health and social care subjects; however, this approach also reduced the number of references to screen by around 400. As mentioned earlier, the number of final

hits is important to the reviewers who are charged with screening within a tight timeframe. Furthermore, screening studies that are situated outside of social care but imply social care in the abstract is slow and at times difficult.

The use of free-text searching with proximity for certain words to reduce the number of irrelevant citations resulted in studies being missed. At least one study was identified in the British Nursing Index (BNI) that was missed in other databases for the mental health setting transitions topic. Unlike the other database searches, no proximity was used as it was easier to translate the search without it and the relative yield of search results was low. Another reason for missing studies was the absence of one search concept. For example, one study was not found in SPP because it had no transition terms.

There were also other limitations from the databases. Abstracts were absent from citations in some databases but were present in others. Two citations were not found in HMIC owing to a date limit being applied to the search, and these two citations did not contain a date in the date field. (The date was included in another field.) Searching the notes field in addition to the abstract field would have been helpful for this database. Furthermore, two items in two databases were found at the time of searching but were not present when checked at a later date.

Discussion

While some findings are largely technical and specialist, they have a direct relevance to policy and practice. With the aim to develop research-based social care and increase our understanding of cost-effective services in this field comes the need to search efficiently and effectively for relevant research.

Key Challenges and Implications

The development of guidelines is largely underpinned by methods developed within the health field, and following these within a social care framework can be challenging. Our analysis shows that it is possible to conduct systematic and useful searches for social care guideline development within this context. Because most of the questions were driven by their relevance to practice, it was not clear how well some areas were researched. Having a potential paucity of literature, coupled with challenges in identifying it, drove the searches to be sensitive within resource constraints. This might not be possible to achieve or appropriate for all social care guidelines.

Designing search strategies for the three guidelines in this analysis was challenging because they asked a range of questions across broad topics about both individuals and services and encompassed multiple outcomes. However, our searches were able to capture most of the evidence from the collection of databases searched. Collective searches identifying literature for several questions within each guideline topic meant that fairly sensitive searches could be undertaken. The contribution of studies sourced outside databases was fairly low for the topics on child to adult services and mental health setting transitions. This could be due partly to the sensitivity of the databases searches and partly that less relevant literature existed outside the databases. This is surprising, given the challenges encountered in translating the concepts of transitions into search terms for the database searches. In contrast, for the homecare topic, 23% of literature was identified from supplementary searches outside databases, though just 4% of literature was not actually present in the databases.

Attempts to increase precision of database searches meant that some citations were missed within individual databases, but our analysis shows that searching across multiple databases mitigated this problem. This was aided by the large amount of overlapping and relevant content found across the databases.

Utility of Major Topic-Focused Bibliographic Databases

Choosing which databases to search is based on a number of factors, including likelihood of high yields, unique yields, convenience to search, sensitivity of the search available, functionality of the databases, and combination of databases searched. From this study, the trend points to using MEDLINE for currency and precision of searches; EMBASE, HMIC, and SPP for unique content; PsycINFO for mental health topics; BNI for broader searching; and CINAHL for studies on people's views. SSCI yielded more relevant studies than other social sciences databases and located some studies not found in other databases. The keywords plus field in SSCI (which is generated from the reference list of each citation) proved useful to search as an alternative to an indexed controlled vocabulary. ERIC was important for education topics. We observed there are potential issues with applying date limits, and as such, in some databases, it is prudent to check this by comparing the search results with an exclusion search of citations outside of the date limits required.

Inability to locate some citations varied according to database, topic, and individual citations in our analysis of the child to adult services and the mental health setting transition topics. Searching the following eight databases for the two topics would locate all the studies: BNI, CINAHL, EMBASE, HMIC, MEDLINE, PsycINFO, SPP, and SSCI. This same combination could potentially locate all the studies from homecare; however, complete data is not available to check this with the original searches. Over 20 databases were searched for each guideline, and our findings suggest a potentially smaller number of databases would yield the same results. This information is particularly useful in undertaking further searches in areas related to these topics and for update searches of the guidelines. Given that the most useful databases vary depending on topic, these findings are tentative when applying to other topics.

It is important to be aware of specialist resources relevant to a topic, and this is not fully considered here. For example, for the child to adult services guideline, the NSPCC Inform child protection database was also searched, and searching trials registries and systematic review databases is often appropriate. However, the aim of this study was to consider general topic-specific databases rather than specialized sources.

Context with Other Research

To locate social care studies, flexibility of approaches is needed in developing search strategies. This study shows this, and so have others (Clapton, 2010; Forbes & Griffiths, 2002; McNally & Alborz, 2004). Our findings on important databases to search are consistent with five of the six important databases from Golder et al. (2008), which related to respite care for carers, though we did not investigate AgeLine. Our study also confirms there are still difficulties with lack of abstracts.

Although it is accepted that multiple database searching is important, our study informs practice on which databases might be more useful to focus on when carrying out literature searches in social care topics, with the caveat that every new topic faces the challenge of articulating a search, finding suitable search terms, and knowing where to find studies. Our results also highlight the variability in indexing studies across databases. It further suggests variability of indexing within databases on social care topics, within the broad remit of the guidelines included here. Analyzing the citations present within databases by their study design was undertaken to explore the usefulness of these databases to inform particular types of questions. The findings particularly highlight the predominance of citations of studies about people's views in certain databases; however, the ability to identify these particular citations from the actual searches is not tested.

Limitations of This Research

There are a number of limitations to the findings presented here. Two databases, HMIC and SPP, are particularly rich in U.K.-relevant content, so their applicability and coverage to social care topics from other countries are unclear. Given that the majority of studies on people's views and experiences were intentionally selected from the U.K. this influences transferability of findings to other countries. It is also worth considering that some studies in the guidelines contributed more than others, and analyzing the influence of these goes beyond the scope of this analysis.

The citations of research evidence used in the analysis were from the search strategies developed for the guidelines and were not compared with other search strategies. However, as part of the guideline development process, the Guideline Committee and public stakeholders have the opportunity to provide research evidence that may have been missed.

Understanding where citations are most likely to be found informs decisions on utilising specific resources. This is particularly useful for topics that are difficult to search for or where a paucity of literature is anticipated. However, only assessing where items present does not provide a complete picture. For example, although ERIC contained 9% of studies from the child to adult transition topic, the sensitivity and practicality of searching ERIC with our search strategy is not known. Using ERIC was important to locate one study for the mental health settings transitions topic, but a deliberately precise search was used. The utility of the interdisciplinary database Scopus was not fully explored here; it was found, post-hoc, to contain a majority of citations for all three guidelines, including 95% of citations from mental health settings transitions topic, though the sensitivity of a search needed to capture these is unknown. A final limitation is that this study compares three guidelines undertaken at different points in time. Differing date limits were used across review questions, with a focus on recent literature where this was considered appropriate. CINAHL Plus was used in the analysis of where citations were present in which databases, but only CINAHL (which has less content) was searched for the child to adult services guideline.

Conclusions

Developing guidelines and systematic reviews in social care involves identifying social care research that is relevant, but not limited, to integrated health and social care services. Broad questions to inform integrated or multi-disciplinary service development are challenging to articulate into concepts that can be translated into terms for searching and require considerable thought and development. For social care practitioners who want to use evidence in their practice and for policy makers in the same field, guidelines informed by evidence reviews and systematic reviews are good ways of grasping a coherent body of literature. Therefore, it is important that the challenges of identifying such literature through systematic searching are addressed. This study highlights challenges and reveals trends in identifying social care research from database sources. There is variation in the ability of the search terms to capture the studies from individual databases, even with low-precision searches. However, this is mitigated by searching a combination of databases and searching other resources and websites that are specific to individual topics. We identified a combination of eight databases that were important for finding literature for these topics. Multiple database searching also mitigates issues related to the currency of content, topic and study design focus, and consistency of indexing within individual databases.

Author Contributions and Acknowledgements

CS conceived of the study and undertook the main analysis. CS and KL reflected on the findings and drafted the manuscript. An earlier version of this study was presented by CS at the European Association of Health Information and Libraries (EAHIL), Seville 8-10 June 2016. Thank you to Catherine Swann, Sarah Lester, and Ginny Brunton for their feedback on the early work.

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ORIGINAL ARTICLE

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Synthesis Methods

Text mining for search term development in systematic reviewing: A discussion of some methods and challenges

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Using text mining to aid the development of database search strings for topics described by diverse terminology has potential benefits for systematic reviews; however, methods and tools for accomplishing this are poorly covered in the research methods literature. We briefly review the literature on applications of text mining for search term development for systematic reviewing. We found that the tools can be used in 5 overarching ways: improving the precision of searches; identifying search terms to improve search sensitivity; aiding the translation of search strategies across databases; searching and screening within an integrated system; and developing objectively derived search strategies. Using a case study and selected examples, we then reflect on the utility of certain technologies (term frequency-inverse document frequency and Termine, term frequency, and clustering) in improving the precision and sensitivity of searches. Challenges in using these tools are discussed. The utility of these tools is influenced by the different capabilities of the tools, the way the tools are used, and the text that is analysed. Increased awareness of how the tools perform facilitates the further development of methods for their use in systematic reviews.

KEYWORDS

clustering, information retrieval, systematic search, text mining

1 | BACKGROUND AND AIMS

Database searching is a core requirement when undertaking many systematic reviews, and the choice of search terms used is key in identifying relevant literature in a systematic way. Identifying search terms to locate an unknown body of literature is challenging, particularly for literature that uses diverse terminology or is not consistently indexed. For example, in a literature review about services and systems to promote the self-care of minor ailments, a range of conceptual perspectives and vocabulary describes “self-care,” including “self-help,” “seeking information,” and “treat at home.”¹ Developing (combinations of) search terms for this type of review is often an iterative process, which can be aided by analysing patterns in samples of text to assess which words or phrases can capture relevant studies and to find ways to

minimise the number of irrelevant studies retrieved. The process is imprecise and database searches are normally supplemented by other search methods including the checking of reference lists and citations and contacting key informants. However, the evolution of sets of search terms can involve a variety of techniques, including knowledge of the literature, published preexisting searches in related areas, topic expertise, database thesauri, iterative searching, browsing citations within databases, and—the focus of this paper—text mining.

“Text mining” in this paper describes a variety of processes that enable discovery of words and patterns in collections of text. Advantages of using text mining tools for a literature search may include supporting the scanning of a large corpus of preliminary results for identification of keywords and subject terms with the potential to improve search strategies; improving time efficiency; and, in some cases,

providing a reproducible, objective method (as opposed to human-developed search strategies that rely on experience or knowledge of the users).² There are indications from the literature on search filter development that user-derived “intuitive” search terms are not always the most suitable terms for using in a search strategy^{3,4} and analysing text or relevant citations might be useful in countering this problem. For example, text mining helped to identify relevant search terms for a systematic review on the broad topic of community engagement, beyond the list of terms that the authors developed themselves.⁵ Two analyses within the separate disciplines of health⁶ and software engineering⁷ found that text mining can be used to obtain studies that were not obtained from researcher-derived search terms in the original search strategies. However, Hausner et al⁶ found that both user-derived approaches and an objective approach that relied on text mining for informing the search terms could each miss some relevant references in reviews on certain nondrug intervention topics. Thomas et al⁸ observe that, through text mining, “the range of search terms can be expanded in a way that better describes the literature in the review.” However, they also point out that “its limitation is a function of its strength: It expands the review in favour of the literature that uses the same language as the documents that have already been found.”

Paynter et al² undertook an overview of text mining tools and techniques in systematic reviews and identified 111 tools, of which 52 support searching. They concluded that “although it seems promising, text mining has not become a standard tool for creating systematic review search strategies” (p. 13) and noted that one possible limitation was that many tools have been developed based upon output from PubMed or Medline. These databases are typically used in development because they are large, well-structured, open datasets. However, systematic reviewers often need to work across many databases, and databases differ in how they structure citations and controlled vocabularies. This may reduce the generalisability of tools that have been developed on the basis of limited datasets, as they may not transfer well to other databases (and domains).

It is important to be aware that the application of text mining for search strategy development is distinct from the related area of search filter development that requires considerable investment in terms of developing gold standard sets of literature upon which to build and test filters. In contrast with search filters, search strategies for specific systematic reviews are often developed for specific reviews and need to be developed relatively quickly. However, there are lessons from filter development using text mining that can be applied to search strategy development. For some specific topic areas, developing filters using word frequency analysis is challenging, and sometimes impossible, as shown by attempts to develop a filter on road safety interventions⁹ and health-related social values.³ Some search filters for

topics that are described by diverse terminology have been developed combining both text mining and expert knowledge or manual processes, for example, alcohol-impaired driving,¹⁰ prognosis of work disability,¹¹ and overviews of systematic reviews.¹² In addition, terminology also needs to be considered in context. For example, Kok et al¹¹ and Petrova et al³ observed their topic search filters behaved differently across different health conditions.

Given the challenges in creating search filters from representative samples of literature on a topic, text mining is considered here as an aid rather than a complete solution for informing search strategies for topics that encompass a range of conceptual perspectives or are described by varied vocabularies. This complementary approach also mitigates potential bias from the sample of literature used for text mining, which may only help identify more of the same literature. There seems to be a paucity of published literature on text-mining procedures for identifying free-text and controlled terms for specific databases using generic tools, although EUnetHTA¹³ and Gourlay¹⁴ provide some guidance on obtaining term frequencies. Controlled vocabularies can also be analysed using database specific tools, particularly for Medline and PubMed, and these are listed elsewhere.^{2,15} However, there is little guidance on using the variety of text mining tools available to complement other methods to identify search terms for undertaking systematic reviews.

The aims of this paper are to (1) give an overview of the main applications of text mining for search term development; (2) reflect on the usefulness of some technologies through a case study and further examples; and (3) discuss the challenges in using these tools. We hope this will promote further debate and dissemination of techniques and methods.

2 | AN OVERVIEW OF APPLICATIONS OF TEXT MINING FOR SEARCH TERM DEVELOPMENT

The purpose of this section is to provide an overview of the main applications of text mining for search term development. To do this, examples of the application of text mining for search term development in reviews were identified from the following sources: items screened for a systematic review on text mining for screening¹⁶; focused iterative searches of Google and Google Scholar; citation searches of literature found; browsing the repository SRtoolbox.com; and discussion groups, such as the Cochrane Information Retrieval Methods Group.

The types of applications identified for text mining for search term development are shown in Box 1. These show 5 groups: increasing the sensitivity (or recall) of a search; increasing the precision of a search; aiding translation across databases; searching and screening within an integrated

system; and using text mining as the predominant method for “objective searches.” Objective searches are outside of our focus here and are described by Hausner et al.^{6,17,18}

Text mining can be used to increase the *sensitivity* of a search by identifying more words, word forms, or phrases, to broaden the range of studies that contain relevant records.^{5,7,21} This might be targeted on certain elements of the search, for example, Damarell et al.²¹ identified potential search terms in the titles and abstracts from records only retrieved by a database's controlled vocabulary and not by known free-text terms.

The *precision* of a search can be improved by identifying phrases or combinations of words rather than a single word on its own, such as Thompson et al.,¹⁹ or by identifying themes of unwanted items through automated clustering.²⁰

For *aiding translation* across databases, Damarell et al.²¹ used text mining to capture items from PubMed not indexed with controlled Medical Subject Headings; however, this could have wider applications in assisting development of search strategies across other databases. The reverse of this approach is also used where citations identified from searches of free-text fields in a database are analysed for suitable controlled vocabularies.

Mergel et al.²² describe SLRqub, as a proof of concept, as a tool to enable search query building of the software engineering research repository, IEEEExplore Library. The tool uses the results from a search and manual assessment by the user of relevant and nonrelevant studies, to suggest search terms and facilitate further searching and screening within the repository. Such an approach could be possible for reviews in different disciplines, once the included studies have been determined, although it is likely to be more resource intensive, particularly where many databases have been searched, and it may be difficult to apply if the search terms are made up of multiple components.

Although presented here as distinct applications, these applications could be used in combination and iteratively during search term development, or perhaps to analyse subcomponents of a search. They could also potentially be used on a set of screened records, either as quality assurance⁵ or as part of an integrated searching and screening system.²²

3 | TEXT MINING TOOLS USED IN THE FOLLOWING CASE STUDY AND EXAMPLES

In the case study and examples below, text mining was applied in 2 of the 5 applications from our framework above: improving the precision of searches and identifying search terms to improve sensitivity by determining both useful and undesirable search terms and phrases to help refine the search strategy. Text mining was used as a part of designing the search strategies, but significant human input was also involved in designing the search, choosing search terms, running test searches, and browsing results.

Generic text mining tools that are not reliant on datasets for specific databases were used. These were readily available to explore their utility and do not require specialist computer science support to use. They were identified in various ways: from EPPI-Reviewer, professional networks, and browsing the literature. We consider these tools to represent some fairly standard analytical options that are currently available.

We start by describing briefly various categories of text mining tools and situate the tools mentioned in this paper within these categories. The text mining tools explored here centre around 3 distinct types of technology: term frequency; automatic term recognition; and automatic clustering.

Term frequency involves obtaining frequencies of word occurrence and cooccurrence. *BibExcel*²⁴ can generate a word list showing how many citations contain specific words (for example, the separate words “disability,” “disabled”); the stem of a word (for example, “disab”); and cooccurring words. Some reference management software can be used to generate lists of controlled vocabulary rapidly through its subject bibliography function²⁵; in the case study, we used *Endnote*. Concordance tools, such as *AntConc*,²⁶ can reveal collocates (words within a certain distance of other words) and N-grams (sequences of n words) within large volumes of text, and for individual citations. *Voyant Tools*²⁷ is a collection of concordance tools, and some of these also use visualisation to show the proximity of words with one another or the relative frequency of words. Another approach is to obtain a statistical measure of the importance of a word, in relation to its occurrence within a text, using the metric “term frequency–inverse document frequency” (TF-IDF).

Box 1: Applications of text mining

Application

Increasing sensitivity: Identifying more words, word forms, or phrases^{5,7}

Increasing precision: Identifying combinations of words¹⁹ or phrases; identifying words from clustering to “safely” exclude terms at low risk of missing studies²⁰

Aiding translation across databases: Identifying free-text terms from records that would not be captured by the controlled terms²¹

*Search and screening within an integrated repository system*²²

Developing objective search strategies, where all the search terms are derived from a suitable sample^{6,17,18,23}

A related, but distinct, approach is *automatic term recognition*, where a tool such as *Termine* combines statistical significance of words with a “part of speech” parser to make linguistic associations from text.²⁸ NaCTeM's Web demonstration tool of *Termine* presents terms and phrases as a ranked list on the basis of its C-value (a statistical measure of the frequency and significance of term occurrence) and as an annotated text showing the terms that have been extracted by the tool.²⁹

Automatic clustering analyses the distribution of terms (words) in small bodies of text (such as, titles and abstracts) and identifies groups of documents that use similar combinations of words; a descriptive term is applied to each cluster to aid human interpretation.³⁰ We used the *Lingo3G* algorithm clustering utility from CarrotSearch.com,³⁰ which is integrated within EPPI-Reviewer 4. It can generate clusters and hierarchical clusters or “subclusters within clusters,” depending on user preference. Citations may be present in one or more clusters, depending on the word combinations that are grouped together.

In the case study and examples below, the text mining tools used were generally open access with the exception of Endnote and Lingo3G. We used TF-IDF and Lingo3G automated clustering tool within the noncommercial subscription-based review management software program, EPPI-Reviewer 4.0.³¹ *Termine* was used through the NaCTeM website.²⁹

4 | CASE STUDY: USING TEXT MINING TOOLS AND TECHNIQUES FOR DEVELOPING A SEARCH STRATEGY

In the case study, we compare the use of individual text mining tools and techniques to increase sensitivity through identifying suitable search terms and to increase precision from examining preliminary outputs of a search for unwanted terms and concepts. The search strategy was developed to identify research literature on the social care and support of adults with intellectual disabilities as they get older. This was intended for a set of evidence reviews used to inform a NICE Guideline on the care and support of older people with learning disabilities.³² It was structured around broad terms for the population at individual and service level (older people, aged care) and health condition (intellectual disabilities, learning disabilities, or named conditions). The Medline search strategy is reproduced in Appendix S1.

4.1 | Increasing search sensitivity: comparison of TF-IDF, Termine, and BibExcel

To identify suitable search terms to increase the sensitivity of the search, 52 study citations known to be of relevance to the

topic area were analysed, collected from exploratory searches on the topic area. The quantity of the citations analysed was less important than the range of research collected. These citations were obtained from screening the results from a series of highly focused searches on areas considered relevant to the guideline and were from PubMed and Applied Social Sciences Index and Abstracts databases. The TF-IDF values, *Termine*, and BibExcel were used to analyse search terms and phrases in the titles and abstracts.

All the TF-IDF values were examined, consisting of 367 items (the value was of 6.5 or higher). *Termine* was used in conjunction with the part-of-speech (POS) parser Genie 2.1, which is customised to biomedical texts, and the first 60% of items in the ranked list was examined, representing 463 items. In BibExcel, words occurring in more than 6 citations were identified and their cooccurrence with another word was collected, which was an arbitrary cut-off point for ease of identifying any patterns in cooccurring words.

The resulting term lists were scanned for potentially relevant items relating to the population concept (older people, ageing) and the condition concept (intellectual disabilities). Suitable words identified from both the TF-IDF and *Termine* analyses were combined and used to search within the 52 items under analysis to determine how many citations would not be identified by these terms, and these citations were checked for potential search terms. Endnote was used to analyse the controlled vocabulary for the 52 citations.

A number of phrases for the population concept were identified from the TF-IDF analysis and *Termine*. As well as terms for older people, phrases relating to literature about ageing were identified, such as “future planning,” “future care,” and “active ageing.” These terms were found to capture 44 of the 52 citations. Manually scanning the remaining 8 citations led to further potential search terms being identified (longevity, ageing adults, menopause, ageing factors, and ageing issues), which further informed the development of the search strategy. Four terms were identified from TF-IDF values and *Termine* that related to the health condition concept, and these located all but 2 records. These 2 records had no distinguishing health condition concept in the title and abstract; one mentioned intellectual disability in the controlled vocabulary field, and one mentioned intellectual disability in the journal title, which informed our strategy to search the journal name field. The final search strategy also included names of more health conditions.

The TF-IDF analysis and *Termine* yielded different results. Both produced a large ranked list of words, although the relative ranking of words differed. Table 1 shows examples of some of the significant words and their relative ranking on the basis of the order in the generated word list. Table 1 also shows examples of some words not identified by *Termine*. The TF-IDF list comprised of a combination of single words and few phrases, and it contained the phrases

TABLE 1 Comparison of selected words from text mining 52 citations from different tools

Phrase	TF-IDF Relative Rank (1 = Highest Rank)	Termine Relative Rank (1 = Highest Rank)	BibExcel Number of Citations—Word Cooccurrence (Minimum Threshold = 6)
Older people	7	n/a	24
Older adult	20	n/a	Older adults = 18
Older person	25	n/a	6
Menopause	10 (menopausal not listed)	“menopausal” at 168	n/a
Retirement	55	72	13
Active ageing	53	18	n/a
Aged care	185	5	9
Community based aged care	128	15	n/a
Future care	281	72	9
Future planning	74	21	n/a

“older people,” “older adults,” “older person,” and “menopause” in the top 30 records. Terms relating to “aged care” were much lower in the list. In comparison, the Termine list did not contain single words and had phrases of at least 2 words. Some phrases describing older people, older adults were ignored by the algorithm, although “elderly people” was ranked 72 in the first 463 phrases checked. However, Termine ranked “aged care” much higher than TF-IDF, at 5 compared with 185. The Termine list included phrases that were not in the TF-IDF list, for example, “late life,” “ageing service,” “future living,” and “future perspective.” There was a difference in which word forms were used; for example, the TF-IDF list contained “menopause,” and 12 instances of “menopause” in the sample were ignored by Termine, (although it identified the phrase “menopause finding” lower than the 60% of phrases checked). However, Termine listed “menopausal” at 168 (in a phrase “carer menopausal attitude”), and this was not present in the TF-IDF list.

For the health condition concept for “intellectual disabilities,” there were very few words from our sample. Both TF-IDF values and Termine revealed “intellectual disability” and “developmental disability.” Termine revealed 2 more conditions than TF-IDF: “down syndrome” (ranked 21) and “learning disability” (ranked 27).

The BibExcel list generated a list of single words. It showed that “older” appeared in 35 out of 52 citations and that “intellectual” appeared in 42 out of 52 citations. The number of citations that contain at least one occurrence of the word or 2 words is shown in Table 1. The BibExcel list was less helpful because most terms of interest were phrases, and single words were too generic, for example, “old,” “future,” “aged.”

4.2 | Increasing search precision

While improving sensitivity helps to ensure that relevant literature is identified, improving *search precision* aims to minimise the identification of irrelevant literature. In this

case, the search strategy was not only informed by text mining but also integrated with search terms obtained from previous work, searches published in the literature, other NICE Guidelines, and iterative searching and browsing of citations from test searches within databases. Various iterations of the search strategy were run in Medline; however, the search appeared to be generating a large number of items irrelevant to the research question. To examine ways in which this could be minimised, and thereby increase precision of the search, 1000 references from a test search were selected by date for 3 types of analysis: (1) Lingo3G clustering to group the citations into labelled clusters; (2) BibExcel to obtain frequencies of citations that contained particular words; and (3) Endnote, to assess controlled terms at various iterations of the test searches.

In analysing the 1000 records in Lingo3G, the 29 clustering labels generated did not reveal anything clearly that could be excluded (an extract is shown in Appendix S2). However, it facilitated examination of citations within the named clusters, such as “Alzheimer’s disease,” to inform judgement on whether some concepts could be excluded from the search.

BibExcel was useful in producing a list showing how many words occurred within a citation. For example, “gene” occurred in 10% of the citations and “protein” and FMR1 each in 6% of citations. These approaches revealed a number of citations on genetic studies and studies concerning mental retardation protein, which were not of interest. Exploring the controlled terms in Endnote also informed further iterations of searches that were tried to remove some of the genetic studies. The final search used some exclusions for genetic studies within the controlled vocabulary for specific disease conditions, and the phrase “mental retardation protein” was excluded where the phrase “mental retardation” was used.

However, these steps alone did not sufficiently increase precision of the search output, although the text mining helped our realisation that the search contained many irrelevant results. Manual reflection was needed to reconsider the search strategy. The final search contained a conceptual

modification to reduce the number of unwanted clinical studies, where the terms for specific conditions were required to be in close proximity to certain population or service user terms.

5 | FURTHER EXAMPLES OF APPLYING TOOLS IN SELECTED SYSTEMATIC REVIEWS

To complement the findings of the case study, we reflect on the usefulness of some technologies beyond those identified in the case study above through some further examples.

5.1 | Increasing precision of the search by combining multiple tools

When refining the search for a review of self-care and minor ailments,¹ we needed to capture studies investigating primary care consultations but reduce the number of irrelevant studies that would be found from only searching on the term “primary care.” We analysed a sample of 54 records using the concordance tool AntConc, which revealed the more precise phrases such as “primary care practice,” “primary care consultancies,” “primary care centres,” “gp-supervised,” and “gp appointment.” The final search included these terms in close proximity with one another.

In a separate analysis for the same review, we analysed preliminary Medline search results that were limited to one publication year to investigate the presence of themes that were inadvertently captured by the search. Lingo3G clustering of 428 items revealed a cluster “cancer” (which was out of scope for the search), and we identified that this was being located owing to terms for “pain management” and “pain control.” We next used some additional tools to examine the results of a subsequent search and analysis of 410 items from that year, which revealed other terms relating to “pain.” Using a function in Voyant Tools entitled “document frequencies tool,” we noticed that the word “pain” appeared frequently in relation to “chronic pain,” “chronic back,” and “chronic musculoskeletal.” An analysis of MeSH terms in Endnote revealed “chronic disease” and “chronic pain” in many items. BibExcel was used to discover that the word “pain” was in nearly a quarter of the records, and the word “chronic” was in a sixth of the sample. The final search was adjusted to reduce the number of unwanted items from chronic pain for certain conditions. For example, “headache” was searched where present without the controlled term for chronic pain, or it was searched for without the free-text phrase “chronic headache.” Voyant Tools’ Cirrus word cloud tool revealed the presence of “pandemic” in our sample, and although this was less predominant than the words “chronic” and “pain,” it was noticeable from a brief check of the word

cloud. As pandemics were an area outside the scope of the review, we could consider ways of limiting it within the search.

5.2 | Increasing precision of the search through clustering

For a systematic review concerning relationships between exercise and osteoarthritis or chronic joint pain,³³ clustering was useful to aid in modifying the search of unwanted records. A sample of 3655 items obtained from a draft PubMed search was clustered using Lingo3G to assess dominant themes from the records located by the search strategy. This generated 29 clusters; cluster labels that were clearly recognisable as not within scope included “total knee arthroplasty,” “total hip arthroplasty,” and “hip arthroscopy,” which are types of surgical procedures, and “rheumatoid arthritis.” By comparison, a TF-IDF analysis showed that the first mention of “arthroplasty” was ranked 84th in the list of terms. Exploring the clusters led to the discovery that “arthroplasty” was mentioned in nearly a fifth of citations from the test search. The final search was adjusted to reduce the number of unwanted items about surgery and postoperative recovery by excluding items containing surgery and postoperative recovery in their titles from the part of the search relating to osteoarthritis and excluding surgery subheadings from the controlled vocabulary searches. We did not adjust the search terms to exclude for rheumatoid arthritis although some of these would have been reduced through reducing the number of citations on surgery.

In a different systematic review concerning medication errors in children,³⁴ a test search in PubMed yielding 5757 citations was clustered into groups using Lingo3G. This resulted in 28 clusters, and of these, several clusters were labelled with themes that were not included within the scope of the review: “suicide attempts,” “pregnant women,” “illicit drugs,” and “heroin overdose.” Citations were browsed within some of the clusters, and term searches were also used to indicate how much literature there was on a topic on, for example, “pharmacy,” “parents,” “suicide,” “traffic,” and “driving.” As a result, some elements were identified that could be potentially excluded from the search, with care not to exclude relevant items at the same time. These excluded elements related to street drugs, alcohol behaviour, suicide, accidents while driving, and pregnancy.

It was previously reported that clustering was used on a set of records retrieved from a preliminary test search in PubMed relating to the late diagnosis of many health conditions.²⁰ This identified a dominant theme that was not within the focus of the review (the genetic technique of polymerase chain reaction) and an amended search strategy that accounted for this theme reduced the number of records retrieved from the PubMed search by 4% (over 500 records).

The amendment was also applied to databases searches of PsycINFO and CINAHL. A conservative estimate suggests that the additional PubMed records would have taken about half a day for one person to screen, representing a considerable workload saving (and having 2 people check records independently would double this estimate).

6 | DISCUSSION

We now summarise the potential utility and challenges in using these technologies for search term development. In particular, we consider combining TF-IDF and Termine; compare word frequency and concordance tools; discuss the usefulness of clustering approaches; provide a brief description of visualisation and synonym tools; suggest sampling as a particular challenge in applying the tools; discuss considerations in using the tools; and consider potential limitations of this work.

6.1 | The value of combining TF-IDF analysis and Termine

In the case study on the care and support of older people with intellectual disabilities, TF-IDF analysis and Termine were both found to be beneficial in identifying terms for one search concept (related to ageing). However, as each had differing results, their use is complementary to one another. Unlike TF-IDF, the Termine point of speech (POS) parsers are not intended to identify every word; in our example, the Genie 2.1 POS used here did not recognise phrases for older people or the term menopause. With the TF-IDF analysis, some terms of interest were either missed owing to parsing some phrases as single words, because the word was not significant in the body of text analysed. For both Termine and TF-IDF, the manual process of scanning the term lists has potential to miss items through a user either by not recognising terms or phrase fragments as significant or by not scanning the lower-ranked terms in the list. However, missing terms can be partly mitigated by iteratively using a technique of searching for citations not located by the search terms and reanalysing successive citations.

O'Mara-Eves et al.⁵ observed that a small challenge is deciding on the threshold below which terms identified by Termine would not be considered, and they used a threshold C-value of 5 when analysing the full text of 5 papers. Their rationale was that "it was the common value below which mined terms seemed to lose relevance across the five papers" (p. 53). Such thresholds are ultimately subjective and cannot be standardised across reviews, as terms with lower rankings might be relevant in some instances because the distribution of C-value scores returned will differ from corpus to corpus. For the review about self-care of minor ailments

(Richardson et al.,¹), Termine was applied to 51 title and abstract citations, initially using a threshold C-value of 5, which identified 22 citations; but then relevant terms that located more records were identified by those with a C-value between 2 and 5, identifying 40 out of 50 citations. With this technique, the C-value threshold used is less important as this is not the sole method for generating search terms.

6.2 | Comparison of word frequency and concordance tools

BibExcel was particularly useful for obtaining the frequency of citations that contain particular words that were indicative of citations that were not of interest. A tool to analyse phrases giving the frequency per citation would have been better, had we wanted to consider this further. This is possible with AntConc, which has more functionality than BibExcel for analysing words in text. We have shown that AntConc can provide more informative analysis of assessing phrases and colocated words within a specified distance of each other.

6.3 | The usefulness of clustering approaches

Clustering can generate groups of citations rapidly. It draws upon the most dominant themes depending on the uniformity of the discriminating terms. Clustering is not as useful in a body of literature where the terms are interconnected or there is no dominant vocabulary to express a collection of unwanted (or wanted) items, as shown in the case study on older people with intellectual disabilities. However, in the other examples described, there were clear dominant themes that were unrelated to the area of interest, and these could be identified and attempts made to address this in the search strategy. From these experiences, we conclude that it is difficult to predict in advance when clustering might be useful.

We previously observed that 2 hierarchical tiers of clusters to be better than one tier for exploring themes in the dataset, as this provided better differentiation of topics.²⁰ However, in obtaining an overview of the literature for assessing the performance of the search strategy, it can be useful to have both single and 2 tiers of clusters to explore, as the single tiered clusters allow the collection of citations within an overarching cluster label to be observed.

Within a clustering algorithm, there are 2 separate processes. The main process is core clustering, which is typically a mathematical analysis of the distribution of terms. The second process is finding a good label to describe the clusters. The Lingo3G algorithm has addressed both these aspects, but when evaluating the utility of a given clustering solution, it is important to bear in mind that both are being evaluated at once. Other clustering algorithms such as latent Dirichlet allocation may identify more coherent clusters than Lingo3G (ie, are better at finding the similarities between

groups of citations), but as they do not identify simple labels—but offer ordered lists of terms—significant user interpretation is needed to identify *why* particular groups of citations have been put together.³⁰

6.4 | Visualisation tools

It is possible to link the output of text mining to visualisation tools, such as word clouds. While this may provide a quick overview and have visual appeal, it is unclear how these could offer more meaningful information than a ranked list of terms or phrases. For example, when words are presented at different angles and in a range of colours, it could be easy to miss some important words. However, this might improve with development and integration with other tools. The Cirrus word cloud tool allows user control of the number of highest frequency words that are displayed, offering some flexibility of appearance. Some visualisation tools, such as VOS-Viewer, can show keyword cooccurrence networks, where the distance between 2 terms provides an indication of the number of cooccurrences.³⁵ As such, it may reveal possible areas of citations containing unwanted items in a search. For example, Glanville³⁶ showed that the word “recruitment” was present in a search sample in conjunction with the separate concepts of clinical trials and molecular biology.

6.5 | Synonym tools

Distinct from these tools are other tools that rely on an external corpus of literature to provide relevant terms (by “external corpus,” we mean a corpus of studies outside of the review). A noticeable absence from the literature concerns tools that identify synonyms or homonyms, particularly outside the medical literature; such tools rely on an external corpus. For example, NaCTeM's History of Medicine semantic search system includes synonyms and a range of other semantically related medical terms,³⁷ drawing on 2 archives of historical medical text. Such tools have the potential to provide a more objective perspective of appropriate search terms within an area, beyond those obtained from a user-derived sample.

6.6 | Sampling as a particular challenge in applying the tools

A key challenge is using a suitable sample of studies to analyse. Careful consideration is needed to avoid introducing selection bias. If the purpose of text mining is either to increase sensitivity or ensure that the search is of a good standard, there is potential for this process to instigate a situation whereby the sample used may only reveal more of the same, or what one expects to be there, because of the way the sample was collected in the first place. In the case study

and examples described here, the samples of studies were collected to increase sensitivity for selected topics that were difficult to describe, and they were not intended to identify all of the search terms. The quantity of citations collected for the sample was arbitrary, although the samples were intended to comprise of a range of relevant concepts. If text mining is being used to refine a search, perhaps to reveal unwanted items in a collection of research for the purpose of increasing precision, the sample might simply be the citations (or subset, or specific timeframe of citations) from a test search strategy or a search line within a search strategy.

The data included in sample are also important to consider. In the examples here, citations and abstracts were used; however, O'Mara-Eves et al⁵ used the full-text of 5 papers that were seminal within the area of their search focus. In some cases, the use of full-texts may not always be possible (for example, limitations in the software, or a lack of known relevant studies) or it might be too inefficient to make the process worthwhile, given that retrieving and then the processing the full-text documents may add considerable time. Whether better quality information can be gleaned from abstracts versus full texts is unknown but is dependent on the breadth and depth of relevant terms used in each, which cannot be known in advance and will likely vary from citation to citation, and review to review.

6.7 | Considerations in using the tools

Where text mining is applied to a collection of citations and abstracts, it is particularly useful to understand how many citations relate to a given term, to indicate the relative impact of a term in locating the items from a search. Without knowing how many terms a given citation is responsible for generating, the terms from long citations or documents with repeating words may be overrepresented within a sample and appear high in a ranked list, even though they might only relate to one citation. In using the above tools to improve precision, rapidly generating this information from BibExcel and Endnote helped inform whether it was worth spending time exploring specific words in the search.

The text mining tools and techniques used here were applied quickly, with the bulk of the time spent on analysing the results. The iterative process of developing the search strategies took time, as they had particular challenges in achieving a search that balanced sensitivity and precision. Using text mining tools alongside other methods for search term development requires additional time input, although it is difficult to quantify how much additional effort is involved. Partly, this depends on the complexity of the search task and the extent of text mining undertaken. Related to this is judging how best to use the tools for a particular purpose and when to stop developing the search. The time required for both will vary depending on the familiarity of the user

with the tools and approaches used. However, the additional time has potential to improve the quality of the search and potentially reduce the volume of records retrieved—thus saving time further into the review process.

For most tools used, an element of preprocessing of the citations within a reference management tool was needed to analyse specific citation fields (such as titles, abstracts, and keywords); although this was not onerous, some familiarisation with the process was needed. If we wanted to find out how many citations in a sample a term related to, some tools (for example, Termine) required multiple steps, such as combining the tool with citation or review management software to “search within” to obtain the relevant citations.

The process of generating terms from a prepared sample using Termine or TF-IDF analysis takes less than a minute and little learning time on its use is required. A drawback of AntConc is that additional processing is required to separate records into citations,³⁸ accessibility can be hampered by institutional firewalls, and some learning on how to use the tool is necessary. In comparison, BibExcel was quicker to apply, although more time was initially needed to understand and develop the steps to use BibExcel because it is a multifunctional tool (Gourlay¹⁴ was a helpful starting point). Also, BibExcel has less functionality as a concordance tool. The Voyant Tools were accessible and rapid to use through their web interface, although some functions do not facilitate understanding how many citations relate to a term, without using citation or review management software to “search within” for that term.

In terms of costs, it would be useful to undertake a full economic analysis of this part of the systematic review workflow, although careful prospective design would be needed to capture the necessary information. Shemilt et al.³⁹ undertook a cost-effectiveness analysis of the title-abstract screening stage of a systematic review but did not examine the impact of different methodologies for constructing the initial search. Unlike the screening stage of the review, search strategy design is an iterative process, influenced by human knowledge and skills, and may be approached in a variety of ways depending on the purpose and resources of a review; these issues would need to be carefully considered in an economic evaluation.

6.8 | Potential limitations of this work

We have not investigated how the use of these tools might interact with, or be supplanted by, emerging tools and methodologies for using machine learning in the citation screening process. For example, we have described above how tools can be used iteratively to improve the precision of a search by identifying terms and concepts that lie outside the scope of a review. It may be, however, that the process of “active

learning,” whereby the machine is able to “learn” to distinguish between relevance and irrelevance would result in a machine learning model that identifies irrelevant terms automatically; thus, the incremental time saved in reducing the search yield using the methods described in this paper may be reduced. However, this would probably mean accepting machine judgements for excluding some citations without any manual checking—something which may require more empirical evidence before it be adopted widely.^{16,40} It also means accepting uncertainties on the potential size of the literature that needs to be screened manually. In the case study, the search was developed for multiple questions and, because the screening was undertaken manually, there was a need to tailor the search to the resources available to screen.

Finally, the case study set out to compare the usefulness of different tools in aiding search term identification and increased understanding of the advantages and limitations of their use. The other examples presented were selected to show where text mining tools have been useful, as they were documented as part of the process of developing the search strategies in the reviews concerned. However, this does not give a comprehensive picture of situations where the use of these tools was *not* useful, as such instances were not documented. From the examples here, it seems difficult to predict how useful text mining may be for individual search strategies, particularly for diverse literature, owing to the nature of language and the potential studies of interest. Nonetheless, by using fairly rapid, easily available tools, text mining is likely to be an appealing approach to complement other search processes.

7 | CONCLUSION

This paper identifies 5 applications of text mining for search term development: increasing sensitivity and increasing precision of searches, aiding translation of searches across databases, searching and screening within an integrated repository system, and developing objective search strategies. Using a case study and further examples, the paper explores the usefulness and challenges of using some text mining tools for 2 applications: increasing sensitivity and precision. We found that text mining can aid the discovery of search terms for search strategies for diversely described topics to support an iterative search strategy development process. Using multiple tools appears to be particularly fruitful. Their usefulness is influenced by the varying functionality of the tools used, the way that they are used, and the text that is analysed. An awareness of how the tools perform can help use them more efficiently and effectively, although the overriding challenge of finding efficient ways to identify an unknown body of literature for incorporation in systematic reviews still remains.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article.

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COMMENTARY

Open Access



Exploring issues in the conduct of website searching and other online sources for systematic reviews: how can we be systematic?

Claire Stansfield^{*} , Kelly Dickson and Mukdarut Bangpan**Abstract**

Websites and online resources outside academic bibliographic databases can be significant sources for identifying literature, though there are challenges in searching and managing the results. These are pertinent to systematic reviews that are underpinned by principles of transparency, accountability and reproducibility. We consider how the conduct of searching these resources can be compatible with the principles of a systematic search. We present an approach to address some of the challenges. This is particularly relevant when websites are relied upon to identify important literature for a review. We recommend considering the process as three stages and having a considered rationale and sufficient recordkeeping at each stage that balances transparency with practicality of purpose. Advances in technology and recommendations for website providers are briefly discussed.

Keywords: Systematic reviews, Information retrieval, Website searching, Online searching, Information management

Background

Many systematic reviews use topic-specific bibliographic databases to identify literature in a 'systematic' way. The functionality of these databases facilitates highly structured Boolean searching, automated recording of search history and bulk exporting of results. These functions support transparency, accountability and reproducibility of the search process, in line with accepted principles of literature searches for systematic reviews [1, 2]. However, literature is often sought outside of bibliographic databases, regardless of subject discipline or methodological focus of the review. Approaches might involve searching websites, search engines or online repositories and typically require searching and browsing (reading and navigating) techniques that differ from approaches to searching bibliographic databases. In comparison with bibliographic databases, there are greater challenges in deciding which websites and online resources to use, running complex searches, exporting search results and

documenting the process. Problems encountered when searching websites with limited search functionality include large search outputs, empirical research hidden on websites within a wealth of other material and lack of abstracts [3]. Where websites are relied upon to identify important literature for a review, it raises the issue of how the search is transparent, accountable and reproducible.

Our focus is on websites and online resources outside academic bibliographic databases. We use the term 'websites' in a broad sense to refer to online resources that lack the functionality to carry out complex Boolean searches, or export results, or do not readily provide a search history. Such resources vary widely in terms of appearance, functionality and content. They include websites of organisations, institutional repositories, research registers, online library catalogues and internet search engines. The value and rationale for utilising these resources varies between reviews and within review teams. Other complementary searching approaches include asking key contacts and authors, hand-searching journals, cited-reference searching and checking references.

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We previously observed that relevant literature for low- and middle-income countries, such as working and policy papers, is often not included in databases, and is located from organisational websites, contacting authors or internet search engines [3]. For some systematic reviews undertaken at the Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre), over a quarter of relevant citations were found from websites and internet search engines [4–13]. This finding is based on data from eight systematic reviews, of which four concern interventions in international development [4, 7, 12, 13], and four concern people's views to inform to UK public health policy initiatives [5, 6, 8, 9].

While there is established guidance on conducting systematic searches of bibliographic databases, it is less clear how to approach searching websites for systematic reviews. We briefly describe our approach in Brunton et al. [14] and expand on this approach here. There is some specific guidance on web-searching for systematic reviews published by the Centre for Environmental Evidence [15], with emphasis on using search engines. Other related work is framed around searching for 'grey literature', where the aim is to seek out relevant literature that is not published in academic journals. Haddaway and Bayliss [16] consider grey literature in two forms: unpublished academic research and research that is generated by practitioners. They present different scenarios for undertaking searching for grey literature and suggest resources for each scenario. There are case studies demonstrating approaches in undertaking grey literature searching within public health-related topics published by Godin et al. [17], Mahood et al. [18] and McGrath et al. [19]. Eysenbach et al. [20] provide an approach to internet searching for unpublished clinical trials. There are published studies on searching specific resources systematically, for example, Google Scholar [21–24] and trials registers [25]. Outside of the systematic review literature, Blakeman [26] outlines challenges and approaches for searching Google effectively and discusses other online resources and tools for retrieving research.

The aim of this discussion is to: consider the challenges of searching websites and online resources outside academic bibliographic databases; to present an approach for conducting website searching for a systematic review; and consider how identifying literature from websites can be systematic in terms of being transparent, accountable, and reproducible. All the authors of this discussion have undertaken searching for systematic reviews across the fields of health systems and social care, public health, education, social policy and international development. Our approach draws on our experience from conducting systematic reviews, and supporting other review teams to undertake systematic reviews over many years and is

informed by discussions within our research centre. We suggest website searching should not be considered only in relation to 'grey literature searching' because it can be used as a strategy to identify journal articles not identified from traditional bibliographic database searches. It might also be used to discover journal citations missed by a database search strategy, to compensate for poor access to subscription databases and for journals that are not indexed within any of the databases searched. We propose a systematic approach to the design and conduct of website searching and a method of recordkeeping. It is not our intention to describe methods for using specific resources. Neither is it to encompass reporting the search in a written published report, which is an area for separate consideration, for example, Briscoe [27] explored the reporting of how websites and search engines were searched in health technology assessments. We reflect on our approach in light of other published works, the potential implications of new technologies and make recommendations for website providers. We hope to promote further discussion of methods in literature searching for systematic reviews and other types of evidence syntheses.

How can we be systematic?

Key challenges we encounter when searching websites for systematic reviews are (1) identifying and deciding which resources to search, (2) how to search or navigate them appropriately, (3) assessing the results, (4) deciding which literature to collect from each resource, (5) retrieving relevant literature in a usable format and (6) deciding what information to record for transparency. To help address these challenges, we propose engaging with searching websites for systematic reviews as three stages: (1) planning the search, (2) executing the search and (3) screening records for relevance and managing the results. These stages are distinct aspects that could be used to approach any type of search (e.g. contacting authors, bibliographic database searching, citation searching, website searching). Table 1 outlines the objective for each stage and challenges for undertaking this step when searching websites. We discuss each of these stages in turn, starting with a discussion on the objective of each stage and ways to address the challenges. Overall, many challenges can be addressed by considering the rationale of the approach and having sufficient recordkeeping at each stage to provide some transparency and increased rigour of approach, without the process becoming unnecessarily onerous for its purpose. We consider principles of transparency, accountability and reproducibility within each stage.

Planning the search

Planning the search involves having a rationale to justify and inform decisions on where to search. It also

Table 1 Three stages within systematic searches and challenges for website searches

Stage	Objective	Challenges in undertaking this step for websites and online resources
Planning the search	<ul style="list-style-type: none"> • To have a rationale for searching methods, based on the purpose of the search • Planning where to search, who is undertaking the search and the timeframe of the review 	<ul style="list-style-type: none"> • Discovery of suitable websites to use • Deciding how representative the range of websites need to be in relation to the scope of the review and time available to search
Executing the search	<ul style="list-style-type: none"> • To utilise each resource in a consistent way, and in a way that is appropriate for each individual resource 	<ul style="list-style-type: none"> • Planning how to search when each source is structured differently and may differ in terms of focus and content • Using individual approaches for each website • Searching resources where the functionality for searches consisting of multiple words and Boolean searching is often limited
Screening and information management	<ul style="list-style-type: none"> • To assess literature for relevance (screening or sifting) • To quantify how many items of literature is processed • To report on methods 	<ul style="list-style-type: none"> • Which literature to collect and how much screening to carry out • Limited functionality to transfer results to citation management tools • The level of detail needed for recordkeeping for preliminary screening at source

considers who is undertaking the search and the timeframe and resources available for the review. The role and purpose of website searching compared with other methods of identifying literature informs these decisions. One challenge is knowing about the most appropriate websites to search. Unlike selecting bibliographic databases, which often cover broad topic areas and specific disciplines, identifying appropriate websites is more dependent on the precise nature of the research question and knowledge and accessibility of the websites available. There is a vast range of options that vary in scope, functionality for searching and browsing and volume of content. The choice of websites should reflect those most suitable to the review, and includes deciding how representative of the topic of investigation it needs to be. There is potential for introducing unintentional bias; for example, a review covering low- and middle-income countries worldwide involves searching a combination of websites that span relevant geographical areas, and is not limited to one geographical region. Another bias could be introduced by focussing only on sources relating to a particular stakeholder group, age group, setting, or study design without appropriate reasons. It can take considerable time to search individual websites, particularly those of individual organisations, or those that contain long publication lists. A risk is that the process will not yield any unique or relevant records compared with other searching techniques, and time is spent looking at references discovered elsewhere.

To address these issues when planning the search, some understanding of the resources within a topic area is needed and can be gained in a variety of ways, by consulting methods guidance for undertaking systematic reviews; library resource lists; grey literature resource lists; reports of systematic reviews; topic advisers and internet search engines or already known websites of interest. Godin et al. [15] describe an approach where they used

a series of Google searches to identify 77 relevant organisations and websites. They also used established customised Google search engines, which restrict searching to specific websites; however, some of these only display a small number of the overall search results. Some of the resources chosen will depend on the reason for website searching. Table 2 gives some examples of choosing websites for different reviews. Carefully thinking about different types of websites can help mitigate unintentional biases and limitations can be acknowledged within a search plan. Planning could involve categorising websites in terms of different characteristics such as population focus, geographical coverage, types of literature and study designs covered. Such categorising aids thinking and aids identifying gaps and limitations. Although decisions on where to search may be made at the outset of a review, these could change during the reviewing process if new resources are identified or if it emerges that some resources are not useful or are unwieldy to use.

It is important to consider which review team member will undertake the searches and ensure they have sufficient understanding of the type of information that is being sought from the literature search, as well as skills in locating and managing literature found from the websites. If a review team has a policy of screening publications for eligibility by two people, they need to decide whether to extend this for website searching, and their rationale for doing so; for example, if the aim is for consistency or to help ensure relevant items are not missed. Given the potential variation by individuals in searching websites, it seems easier to operationalise the latter, without striving to match the exact process used by each person.

Another aspect to consider is the time-point of website searching alongside the rest of the systematic review. For example, if the website search is undertaken by a reviewer who has already screened literature against the eligibility criteria of the review, they would have a clear idea of the literature sought from websites. Hammerstrom et al. [1]

Table 2 Examples of choosing websites for different reviews

Systematic review	Key purpose of website search	Types of websites, online resources and depositories
Access to economic assets for women in low- and lower-middle-income countries [7]	Discover relevant research missed or not indexed in international or regional databases	Over 35 sites consisting of government and research-active non-governmental organisations, academic research centres and funders, relating to economics, microfinance, international development, or regional development banks
Adult cooking skills programmes [31]	Discover unpublished evaluations of cooking skills programmes in the UK	Generic search engine, library catalogues, and 25 websites of UK public health and community organisations, research centres and government departments
Depression, anxiety, pain and quality of life in people living with chronic hepatitis C [32]	Discover research identified by advocacy organisations and health research potentially missed by database searches	Websites of hepatitis C advocacy groups in mainly in the UK and some resources to containing healthcare research in general
Realist synthesis of school accountability in low- and middle-income countries [33]	Undertake purposive searching for advisory group engagement and scoping exercise stages prior to bibliographic database searching	Specialist databases, search engine, 20 websites of international development agencies and organisations
Exercise interventions and patient beliefs for people with chronic hip and knee pain [34]	Discover literature on people's experiences, largely unpublished in journals	Range of website resources covering: arthritis groups in UK, Australasia, and North America, ageing care registries, patient experience resource, grey literature resources, generic search engine, social science research

suggest that completing web searches towards the end of the search phase of a review ensures picking up the most current information. On the other hand, searches undertaken at an early stage of the review may inform any bibliographic database searching or other searching techniques that might be planned later. Overall, we think that the searching could take place at any point, depending on what is needed for an individual review.

Executing the search

The objective of searching should be to utilise each resource in a consistent way and in a way that is appropriate for each individual resource. This poses particular challenges for websites because each resource is structured differently and may differ in terms of focus, content and functionality for searching and browsing. It is difficult to judge how to search with confidence that items of interest have not been missed. It is impossible, and potentially unhelpful, to treat each resource in the same way. Each website requires different techniques, for example, browsing relevant web pages, searching using a generic search function, navigating headings within webpages or scanning lists of references. It is likely that more than one approach is needed for each website, and time is needed to develop knowledge and skills to utilise individual resources.

From our experience, the process of recording how a website is searched helps in considering the search approach. The act of recording which navigation headings are browsed and which search terms are used helps the searcher to reflect on their choice and rationale of approach and may prompt useful iteration of searches. It aids structuring a search for each website, encourages a

greater level of care to be taken when searching and enables comparison across different websites. Record-keeping may help in using a consistent approach for similar resources, while at the same time giving flexibility to search each resource differently, as needed. As well as facilitating searching, such recordkeeping provides a degree of transparency and aids accountability and reproducibility for internal documentation. It also enables knowledge and skills gained from using particular websites to inform future searches, for example, if revisiting the same websites at a later date to search using different terms or to update the original search.

We recommend considered recordkeeping with brief descriptions of the techniques used for searching. Table 3 gives an example of recordkeeping in an Excel worksheet. The focus is on recording key elements quickly and efficiently in a way that is understood by the review team. Individuals may have their preferred notations for brevity. The example illustrates a range of approaches taken to identify research on a website of the Alzheimer's Society, a UK research and support charity for dementia. This includes a brief description of the date searched (and last searched, if different), the pathways followed, any search terms used and database fields searched. The notes field provides space for recording additional information. The second resource searched is Rehabdata, an online database on disability and rehabilitation. As well as recording the pathway searched, it is noted that predefined keywords from that resource were used. The uniform resource locators (URLs) for the main websites are recorded in a separate worksheet, but the specific pages can also be recorded within the section on the

Table 3 Example of recordkeeping for executing the search

Name of resource	Searcher	Date searched	Date of last access (if different)	Pathway followed, e.g. browsed headings/ searched site/database within website (use separate lines for the different types of searches)	Used predefined keywords 'Y'	Notes
Alzheimer's Society Research https://www.alzheimers.org.uk/research	CS	3/3/15		Browsed ongoing and completed research on the topic of 'Towards better care for people with dementia'		
		3/3/15		browsed 'living with dementia' research articles		
		3/3/15		Searched dementia catalogue—subject: hospital admissions, hospital discharges	Y	
		3/3/15		Searched dementia catalogue-free text: transition, transitions or transfer		
Rehabdata	CS	3/3/15		Searched descriptor field: Hospitals AND (Psychiatry OR Psychiatric Rehabilitation) AND 1999–2015	Y	

pathway followed. The worksheet also provides space to specify how many literature citations were browsed and saved for further examination, which is discussed under the third stage of screening and information management.

We consider the process of searching and browsing as iterative, as the content within each website might prompt using different search terms, or browsing other parts of a website. Some searches may incorporate a full-text search of a document, which could require adapting search terms to increase the relevance of results. It is important to be aware of user bias in terminology and to use the headings or index terms set by the website provider or consider browsing records to complement using search terms. Establishing a pool of terms to draw on or reflecting on searches for similar websites can help.

Actual searching and browsing methods are likely to differ from review to review. For example, some review teams may adopt a uniform method to apply to specific groups of resources. On the other hand, it may be more appropriate to adopt varying approaches that are individual to a website, but consistent with the overall premise of finding relevant research that meet the criteria for a review. Depending on the content of the resource and how it is structured, it may be appropriate to browse references, rather than run searches on keywords, or use a combination of approaches. Searching some registers or websites focussed on an area of relevance provides an opportunity to search more broadly than is practical with a bibliographic database, as the number of results is likely to be much smaller. For example, for a series of reviews relating to the transition between inpatient mental health and community and care home settings, we found separate searches with the terms 'hospital' or 'psychiatric' specific enough to identify a small number of records on some websites, but too generic to use for others.

Schucan-Bird and Tripney [28] describe separate approaches used for searching websites of organisations, subject specialists, research funding bodies and Google for a large systematic literature search. They adopted a general approach for websites of organisations, which involved browsing all items listed under one section where the publications numbered less than 100, and used a search function drawing on a pool of search terms where they found over 100 publications were listed. In contrast, Godin et al. [17] describe a different approach where they searched a website database or used the search function and hand-searched where these functions were not available. Mahood et al. [18] describe an approach where they compiled a pool of search terms, customised the search and used controlled vocabulary wherever possible. In several databases, a simple strategy of two key terms that could be truncated was used in addition to a full or modified longer set of search terms to ensure a comprehensive search. For online repositories, they used their simple strategy in various fields (title, abstract, where available), with result yields varying from two to over 500 references.

Evaluations on utilising specific resources can guide practice. Glanville et al. [25] studied search approaches for two clinical trials registries, ICTRP and Clinicaltrials.gov, and found single-concept searches in the basic interfaces to be the most reliable. Haddaway et al. [24] investigated approaches for searching Google Scholar, which only displays the first 1000 references of a search; they found that title searches enabled discovery of more grey literature (conference proceedings, theses, reports) than full-text searches. They also found that these types of publications occur later in the ranked list of results than academic journal papers.

Screening and information management

Once a resource is searched, it must be decided which results should be saved for screening (or sifting) for relevance against the eligibility criteria for a review. This stage also involves recordkeeping to quantify how many literature citations have been processed and the methods used for selecting potentially relevant literature.

There is often no function to export results automatically into citation management tools, so challenges include deciding which literature to keep from each resource, how much screening to carry out within each resource and the level of detail for recordkeeping for preliminary screening of results. Manually transferring all the results is possible, but usually some boundaries need to be set on what is transferred; otherwise, it is an inefficient exercise to collect all references, regardless of their relevance, so they can be screened in a systematic way. Furthermore, transferring all results could promote bias in only undertaking highly focused searches, so that the results manageable, and hinder expansive browsing and iterative searches. We expect that preliminary screening within the website is necessary so that only items that are relevant are saved for further examination. In this way, it can be helpful to consider searching and screening as continuous and iterative. Conceptually searching and screening are on a continuum, as they are both aimed at narrowing a collection of research into those most relevant to answer a review question. However, it is important to consider how much transparency is needed in describing the screening of studies at source.

In our opinion, an efficient way to view screening on websites is to seek out only the items that are of likely relevance to a review and record the number collected for formal screening against eligibility criteria, rather than recording the decision made about the relevance of every citation that is encountered. This approach focuses on describing the literature found. It is possible to have some transparency in assessing the results. For example,

indicating whether the literature was assessed for relevance on the basis of the title alone, title and abstract or full text. Where partial lists are browsed, an indication of how that list was organised should be provided (for example, scanning the first 100 items by relevance). Reporting and screening may vary between each resource, as results might be displayed in different ways (for example, a list, a selected quantity displayed by relevance, or chronologically). Where results are scanned by relevance, it depends on user-judgement of how many is appropriate to scan for that particular source.

It is not always possible to know the total number of items scanned in a list (without manually counting). However, in all situations, it is possible to record how many items were retained for further consideration to the literature review. In our opinion, if there is sufficient information on the method used for searching and screening for studies on a website, the precise number of records scanned is of relatively low importance. Table 4 provides an example of documenting this approach. There is space to record whether automated exporting was used, to describe how many results from each search were saved for further screening, how the items were assessed and to record how many items were scanned (if known). However, this approach may not be acceptable to some review teams: Rader et al. [29] observed that in documenting records from non-database sources, some information specialists find it practical only to report those that will be put forward to the review team for screening; others prefer to be precise in reporting every record, even if only a portion of these are included in the final report.

Screening at source may be particularly time-consuming depending on the type of literature or if the results contain a lot of relevant records that have already been identified from other searches. Mahood et al. [18] observe that with non-journal literature, it is sometimes difficult to judge relevance based on titles and abstracts due to missing citation information or abstracts. They also observe that duplicate references from Google and

Table 4 Example of recordkeeping for initial screening and information management

Name of resource	State Y if automated exporting in RIS/XML	If no automated exporting available:			Additional notes
		No. of promising documents	Number scanned	Approach to screening, e.g. title, then abstract/full text OR first 100 ranked by relevance	
Alzheimer's Society Research https://www.alzheimers.org.uk/research		0	n/a	Title	
		0	n/a	Title	
		12	70	Title	
		1	69, 23, 43 items from the searches	Title	
Rehabdata		21	37	Title	

Google Scholar can be difficult to recognise due to different citation formats and missing citation information. One approach we have used with Google Scholar is to individually export the results into a citation management tool and duplicate check these against records collected elsewhere, leaving a smaller number of citations to examine. Godin et al. [17] use a bookmarking system within their web browser to avoid identifying the same record twice as the URL of previously bookmarked pages are starred.

Where an internet search engine yielding vast numbers of results in a ranked order, one must decide how many results to screen. This may be informed by the results returned and then screening to saturation (for example, scanning until no more relevant items are identified on a page or on a following page). Based upon a utility analysis of Google Scholar for seven reviews in environmental science, Haddaway et al. [24] recommend looking at the first 300 results in Google Scholar for academic literature, screening well beyond this to find relevant grey literature and they advocate the use of tools to gain a snapshot of the first 1000 results.

Advances in technology

Advances in technology are likely to increase options for automating website searching, data and document retrieval and recordkeeping in the future. Automated logging tools that store search history, browsing patterns and saving of content have the potential to assist the entire process. For example, the Open Source Internet Research Tool (<http://osirtbrowser.com/>) provides screen captures, a log of the locations and time a webpage was browsed, fields for the user to record their own notes and also facilitates file management. Other tools may be helpful when searching websites. For example, bookmark management and screen-clipping tools can be used to save and organise information. Web-scraping tools, such as import.io, which extract data from websites, are becoming accessible to users without programming expertise, and may be a useful application for exploring and managing the content examined from some websites.

These tools have the potential appeal for reducing manual recordkeeping. However, the elements logged need to be meaningful, and their use could possibly affect the processes of reflection and iteration encountered in searching. Perhaps these processes illustrate two contrasting approaches: (a) targeted hand-searching such as browsing and manual assessment and retrieval of relevant items and (b) capturing large quantities of studies, including many irrelevant studies, using automated tools and filtering for relevance using text-mining technologies. We expect a hybrid of both approaches would co-

exist. Overall, their performance in comparison with manual browsing, searching and document retrieval from individual websites needs to be considered.

Transparency, accountability and reproducibility

Recordkeeping provides transparency, accountability and reproducibility of the process to varying extents. Transparency is achieved by recording brief information on a resource searched, how and when it was searched, the approach to screening for relevant literature and the number of relevant items saved for further assessment. For many systematic reviews, we have captured the information as an internal record of what was done, though it is potentially available to a wider audience. Publishing fuller details of the search process may be appropriate where there is more reliance on website sources than on traditional bibliographic databases. Accountability is achieved to some extent by having a rationale for the resources searched and having a record of how the search was carried out. This rationale is influenced by several factors, such as the knowledge and skills of the searcher, and time and resource constraints under which a review takes place. A related aspect is that recordkeeping helps searchers consider how they are searching, thereby improving the quality of the search undertaken. These factors are largely hidden from an independent reader of a systematic review, but influence the conduct of searches. Reproducibility of searches is achieved to a limited extent whereby the general approach taken could potentially be replicated. However, clear, systematic and replicable approaches to searching might not lead to replicable results, as observed by Adams et al. [30]. Within each resource, reproducibility is limited as the content of the resources, search functionality and underlying search mechanisms are not static. Furthermore, how they are searched depends on the different perspectives and skills of a user. Limitations for reproducibility do not outweigh the advantage of searching these resources, and we suggest a greater emphasis on transparency and accountability is more appropriate.

Table 5 Recommendations for website providers

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- Consider how users can discover the most relevant content
 - Provide instructions or labels for locating research
 - Separate empirical research from opinion pieces and guidance tools
 - Make all search results available
 - Inform users how results are displayed (e.g. relevancy ranked, date published, date added)
 - Provide functionality to export citations into citation management tools
-

Conclusion

We present a process of systematic website searching in relation to problems encountered in making the process transparent. The methods of website searching may differ between systematic review groups; however, we suggest that it is more important to have a considered rationale for the process, taking into consideration the aims and objective for each review rather than specifying a uniform method. The framework of planning the search, executing the search and screening and information management provides both structure and flexibility to this approach. Recording key elements of the process facilitates reflection and consideration and helps researchers work through some of the challenges of searching websites. New technologies offer potential for automating the browsing, searching and document retrieval processes from websites, which are likely to influence current practice. Despite such advances, the core principles of systematic literature review methods remain that require transparency, accountability and reproducibility. There is a need to raise awareness with website providers and organisations to make their empirical research (and other relevant literature) more accessible to systematic reviewers. We have made some suggestions in Table 5. We hope this discussion will help improve methods in this area.

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Appendix 2 Complete publication profile

Publications are listed by publication type in chronological order.

Published book chapters

Brunton G, **Stansfield C**, Caird J, Thomas J (2017) Finding relevant studies. In: Gough D, Oliver S, Thomas J (eds) *An introduction to systematic reviews*. 2nd edition London: Sage

Brunton G, **Stansfield C**, Thomas J (2012) Finding relevant studies. In: Gough D, Oliver S, Thomas J (eds) *An introduction to systematic reviews*. London: Sage

Journal articles

Stansfield C, Liabo K (2017) Identifying social care literature: case studies from guideline development. *Evidence-Based Library and Information Practice* 12: 114-131.

Stansfield C, O'Mara-Eves A, Thomas J (2017) Text mining for search term development in systematic reviewing: a discussion of applications and challenges. *Research Synthesis Methods* 8: 355-365.

Bonell C, Dickson K, Hinds K, Melendez-Torres GJ, **Stansfield C**, Fletcher A, Thomas J, Lester K, Oliver E, Murphy S, et al. (2016) The effects of Positive Youth Development interventions on substance use, violence and inequalities: systematic review of theories of change, processes and outcomes. *Public Health Research* 4:1-218.

Dickson K, Melendez-Torres GJ, Fletcher A, Hinds K, Thomas J, **Stansfield C**, Murphy S, Campbell R, Bonell C (2016) How do contextual factors influence implementation and receipt of Positive Youth Development programs addressing substance use and violence? A qualitative meta-synthesis of process evaluation. *American Journal of Health Promotion*, epub 21 Oct.

Stansfield C, Dickson K, Bangpan M (2016) Exploring issues in the conduct of website searching and other online sources for systematic reviews: how can we be systematic? *Systematic Reviews* 5: 191.

Stansfield C, O'Mara-Eves A, Thomas J (2015) Reducing systematic review workload using text mining: opportunities and pitfalls. *Journal of the European Association for Health Information and Libraries* 11: 8-10.

Oliver S, Bangpan M, **Stansfield C**, Stewart R (2015) Capacity for conducting systematic reviews in low- and middle-income countries: a rapid appraisal. *Health Research Policy and Systems* 13:23.

Brunton G, Paraskeva N, Caird J, Bird KS, Kavanagh J, Kwan I, **Stansfield C**, Rumsey N, Thomas J (2014) Psychosocial predictors, assessment, and outcomes of cosmetic procedures: a systematic rapid evidence assessment. *Aesthetic Plastic Surgery* 38: 1030-1040.

Caird J, Kavanagh J, O'Mara-Eves A, Oliver K, Oliver S, **Stansfield C**, Thomas J (2014) Does being overweight impede academic attainment? A systematic review. *Health Education Journal* 73: 497-521.

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Stansfield C, Thomas J, Kavanagh J (2013) 'Clustering' documents automatically to support scoping reviews of research. *Research Synthesis Methods* 4: 230-241.

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Systematic review reports

Hurley M, Dickson K, Walsh N, Hauari H, Grant R, **Stansfield C**, Cumming J, Oliver S (in press) Exercise interventions and patient beliefs for people with chronic hip and knee pain: a mixed methods review (Review). *Cochrane Database of Systematic Reviews*.

Richardson M, Khouja C, Sutcliffe K, Hinds K, Brunton G, **Stansfield C**, Thomas J (2018). *Self-care for minor ailments: systematic reviews of qualitative and quantitative research*. London: EPPI Centre, Social Science Research Unit, Institute of Education, University College London.

Kneale D, Patalay P, Khatwa M, **Stansfield C**, Fitzsimons E, Thomas J (2016) *Piloting and producing a map of Millennium Cohort Study Data usage: Where are data underutilised and where is granularity lost?* London: EPPI-Centre, UCL Institute of Education.

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Brunton G, Caird J, Sutcliffe K, Rees R, Stokes G, **Stansfield C**, Llewellyn A, Simmonds M, Thomas J (2015) *Depression, anxiety, pain and quality of life in people living with chronic hepatitis C: A systematic review and meta-analysis*. London: EPPI Centre, Social Science Research Unit, Institute of Education, University of London.

Brunton G, Caird J, Stokes G, **Stansfield C**, Kneale D, Richardson M, Thomas J (2015) *Review 1: Community engagement for health via coalitions, collaborations and partnerships: A systematic review*. London: EPPI-Centre.

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Sutcliffe K, Stokes G, O'Mara-Eves A, Caird J, Hinds K, Bangpan M, Kavanagh J, Dickson K, **Stansfield C**, Hargreaves K, Thomas J (2014) *Paediatric medication error: a systematic review of the extent and nature of the problem in the UK and international interventions to address it*. London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

Brunton G, Paraskeva N, Caird J, Schucan Bird K, Kavanagh J, Kwan I, **Stansfield C**, Rumsey N, Thomas J (2013) *Psychosocial predictors, assessment and outcomes of cosmetic interventions: a systematic rapid evidence review*. London EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

Angus K, Murray R, MacDonald L, Eadie D, O'Mara-Eves A, **Stansfield C**, Leonardi-Bee J (2012) *Review 6: A review of the effectiveness of smokefree strategies and interventions in secondary care settings (Draft version 3)*. Retrieved from <http://www.nice.org.uk/nicemedia/live/13017/63461/63461.pdf> on 17 April 2013.

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Leonardi-Bee J, Jayes L, O'Mara-Eves A, **Stansfield C**, Gibson K, Ratschen E, McNeill A (2012) *Review 5: Barriers and Facilitators for Smoking cessation interventions in Mental Health (Draft version 3)*. <http://www.nice.org.uk/nicemedia/live/13017/63461/63461.pdf> [accessed 17.04.2013].

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Caird J, Kavanagh J, Oliver K, Oliver S, O'Mara A, **Stansfield C**, Thomas J (2011) *Childhood obesity and educational attainment: a systematic review*. London: EPPI-Centre, Social Science Research Unit, Institute of Education, University of London.

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Systematic review protocols

Oya C, Johnston D, Skolidou D, Muchiri E, Schaefer F, **Stansfield C**, Dickson K. (2015) *Effects of certification systems for agricultural commodity production on socio-economic outcomes of beneficiaries in low- and middle-income countries: a systematic review* (Protocol. Campbell Collaboration).

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Appendix 3 Description of the sample of ten reviews

This Appendix contains a description of the sample of reviews from which the dimensions of search strategy design were developed. Section 1 describes the sample of ten reviews using the dimensions of difference framework developed by Gough et al. (2012). Section 2 illustrates the themes that emerged from analysing the reviews. Section 3 illustrates how the reviews informed the categories and themes on the influences of search strategy design.

1. Describing the sample of reviews using the dimensions of difference framework

Table A1 describes ten reviews by the dimensions of difference framework listed in Figure 4.2 (Chapter 4). A narrative summary describing the dimensions of difference of the reviews in the sample is presented here in terms of: 1) aims and approach, 2) structure and components, 3) breadth and depth; and 4) dimensions of searching.

How do the reviews differ in terms of aims and approach?

There is variation within the sample of reviews in terms of aims and approaches, structure and components of breadth or depth. In terms of 'aims and approach' reviews 1-3 explore themes on a topic, either of people's views (#1, 3) or the extent of research (#2). Reviews #4-7 both explore themes and test the effectiveness of interventions within a topic, and reviews #8-10 are observational (data are used to observe either statistical significance or prevalence of a phenomena). The reviews also vary in the approach to describing and synthesis: either aggregating (i.e. adds up the findings from studies) or configuring (i.e. arranges findings from studies) or describe the studies without any synthesis (Gough and Thomas, 2012, p51). Although, the approach of aggregation or configuration typically reflects the type of answer required (e.g. themes, or statistical significance), the sample shows some variation. For example, aggregation is used in a study exploring themes of children's views (#1) and configuration is used in a study aiming to determine prevalence (#9).

How do the reviews differ in terms of structure and components?

The structure and components of each review vary: .Three are maps describing the extent and nature of research (#2, 9, 10), several undertake one or more syntheses on all the research included

(#1, 5, 6, 7, 8, 10). One is a map of research and a subset of the research from the map was used for synthesis (#9).

How do the reviews differ in breadth or depth?

The macro-research strategy is intended to describe the breath or depth and whether the work done is adequate, rapid or scoping. This category was difficult to describe as it required a subjective interpretation of the relative breadth or depth of a review. In contrast, describing the resources as adequate, rapid or scoping, was straightforward. For example, the rapid review (#6) was described as a rapid review, but appeared to consider breadth and depth. The scoping review (#8), by implication considers breadth. For the other reviews, they were classed as 'adequate', and the breadth or depth varied.

How do the reviews differ in terms of the five dimensions of searching?

The five dimensions of searching also seemed difficult for characterising the range of differences between each review. For nine of the ten reviews, the "sufficiency of searching" is achieved from taking a comprehensive approach, with the exception of review #3, which takes an emergent approach, comprising an "emergent strategy of searching in response to emergent inclusion criteria" (Gough and Thomas 2012, p60). However, this review is not distinctive in other dimensions: it uses a comprehensive search terms and, although limited databases are searched, time used is classed as adequate, as there was a considerable time planning the search, and follow-up reference checking is an important aspect of the emergent strategy. Even the rapid systematic review (#6) involved a range of resources and comprehensive search terms. This rapid review contained six distinct research questions and the rapid element for this review was largely attained by reducing time spent on other stages of the review following the searching stage. The 'rapid' element comprised of using text mining to prioritise and reduce the volume of citations screened, and limiting the data extractions and synthesis of certain types of studies. For review #10, although only databases were searched using limited search terms, the search was considered comprehensive as 24 databases were searched, and the limited search terms were sufficiently distinctive for aiming to capture all the literature. In addition, for some reviews the extent of website searching, books, reference checking depended on the study types sought, which is not covered by these dimensions. For example, doctoral theses were identified for qualitative research in review #1.

Table A1 Ten reviews and dimensions of difference

	Seven dimensions of difference in systematic reviews							Five dimensions of searching				
	Aims and approach			Structure and components		Breadth, depth and work done		Nature of Sufficiency	Search sources	Extent of search		
#	Approach	Type of answer	Nature of synthesis	Components of review	Relation of component	Strategy	Resources			Range of sources	Comprehensiveness of search terms	Time
1	Exploratory	Themes – variety and quantity	Configurative/Aggregative	Synthesis	Two syntheses juxtaposed	Depth	Adequate	Aggregation and configuration	Range	Databases, journal hand-searches, websites, reference lists, forward citation searching, contact key informants	Extensive	Large
2	Exploratory	Scope of research	Descriptive	Map	n/a	Breadth	Adequate	Aggregation and configuration	Range	Databases and websites	Extensive	Large
3	Exploratory	High-level themes	Configurative	Literature review	n/a	Breadth	Scoping	Emergent	Limited	Databases and reference checking, and recommendation	Extensive	Adequate
4	Exploratory and Testing	What works, acceptability, barriers/facilitators	Configurative/Aggregative	Synthesis	Multiple syntheses, juxtaposed and standalone	Depth	Adequate	Aggregation and configuration	Range	Databases, websites, guideline committee	Extensive	Adequate

	Seven dimensions of difference in systematic reviews							Five dimensions of searching				
	Aims and approach			Structure and components		Breadth, depth and work done		Nature of Sufficiency	Search sources	Extent of search		
#	Approach	Type of answer	Nature of synthesis	Components of review	Relation of component	Strategy	Resources			Range of sources	Comprehensiveness of search terms	Time
5	Exploratory and Testing	What works, acceptability, barriers/facilitators	Configurative/Aggregative	Synthesis	Two syntheses juxtaposed	Depth	Adequate	Aggregation and configuration	Range	Databases, websites	Extensive	Large
6	Exploratory and Testing	What works, barriers/facilitators	Descriptive / Aggregative/ Configurative	Synthesis and map	Six syntheses, and a descriptive map	Breadth and Depth	Rapid	Aggregation and configuration	Range	Databases, journal hand-search Websites, reference checking and cited reference checking	Extensive	Large/adequate
7	Exploratory and Testing	What works, acceptability, barriers/facilitators	Configurative/Aggregative	Synthesis	Three reviews juxtaposed	Breadth and depth	Adequate	Aggregation and configuration	Range	Selective – stage one, and broader range stage 2	Extensive	Large
8	Observational	Statistical significance	Aggregative	Synthesis	n/a	Breadth	Scoping	Aggregation	Range	Databases only	Extensive	Adequate
9	Observational	Prevalence	Configurative	Map and synthesis	Synthesis on sub-section of studies	Depth	Adequate	Configuration	Range	Databases, websites, citation and reference checking, advisory group,	Extensive	Large

	Seven dimensions of difference in systematic reviews							Five dimensions of searching				
	Aims and approach			Structure and components		Breadth, depth and work done		Nature of Sufficiency	Search sources	Extent of search		
#	Approach	Type of answer	Nature of synthesis	Components of review	Relation of component	Strategy	Resources			Range of sources	Comprehensiveness of search terms	Time
10	Observational	Prevalence (within <i>a priori</i> framework)	Descriptive	Pilot systematic map	n/a	Observe gaps	Adequate	Aggregation and configuration	Range	Databases only	Small	Large

2. Developing themes on searching that emerged from the ten reviews

Table A2 shows themes relating to search strategy design, which emerged after extracting data from the ten reviews, and relates them to each review. While the intention is not to aggregate themes, the table locates the themes onto individual reviews. The themes are grouped into categories, which are described in Chapter 4.

Table A2 Elements relating to the search strategy design informed by the ten reviews

Elements/Review	1	2	3	4	5	6	7	8	9	10
Publication formats	Y			Y					Y	Y
Multiple subjects	Y	Y	Y	Y			Y	Y	Y	Y
Full-text search										Y
Nature of title, abstract or index fields	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sector diffuseness				Y						
Diffuse concepts		Y	Y	Y	Y		Y		Y	
Multiple stages of search			Y				Y		Y	
Different types of sources				Y	Y	Y	Y		Y	Y
Selecting resources	Y									Y
Updating other reviews									Y	
Increasing precision		Y	Y		Y		Y		Y	
High sensitivity	Y					Y	Y		Y	
Sensitivity versus implications for screening						Y				Y
Currency/ updating search	Y	Y		Y						
Terminology simple										Y
Terminology diffuse	Y	Y	Y	Y	Y	Y	Y	Y	Y	

3 How the reviews informed the categories and themes on the influences of search strategy design

Table A3 shows how each of the ten reviews informed the categories and themes on the influences of search strategy design.

Table A3 Categories and themes on the influences of search strategy design, as informed by the ten reviews

Category	Reported themes	Review									
		1	2	3	4	5	6	7	8	9	10
People	Advisory group/ committee members	Y			Y					Y	
People	Topic experts on review team		Y			Y	Y				
Process	Scoping work/ protocol iteration				Y			Y			Y
Process	Quality assurance						Y				
Process	Emergent in process			Y			Y	Y			
Process	Searching/screening and protocol iteration							Y			
Process	Test searches							Y	Y		
Resources	External register of likely relevant records for testing search		Y								Y
Resources	Similar systematic reviews		Y							Y	
Resources	Time / rapid review constraints						Y				
Resources/ Evidence	Other search filters or terms from systematic reviews		Y							Y	
Evidence	Selecting a resource based on findings of Stansfield et al. 2012									Y	
Technology	Text mining to increase precision and reduce sensitivity		Y			Y		Y			
Technology	Search interfaces – require two-word searches and browsing	Y									
	Other themes not reported										
Process	Topic familiarisation			Y	Y						
Resources	Availability of resources	Y									
Resources	Browsing library catalogues for sources			Y					Y		
Resources	Browsing websites to decide which to search				Y						
Technology	Specific database fields (e.g. diagnostic tests in PsycINFO)									Y	